THE ADOPTION AND IMPLEMENTATION OF *KAIZEN* IN SINO-JAPANESE AUTOMOTIVE JOINT VENTURES

By

Jie Ma

Newcastle University Business School

A thesis submitted to the Faculty of Humanities and Social Sciences at

Newcastle University in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Operations Management

September, 2013

Declaration

This statement and the accompanying publications have not previously been submitted by the candidate for a degree in this or any other university.

JIE MA

Newcastle upon Tyne

September, 2013

Abstract

This research provided a further insight into the implementation of the Japanese *Kaizen*. It examined the interrelationships between the four building block shop floor management tools (5S, waste removal, visual management and standard operations) and the two *Kaizen* practices (Quality Control Circles or QCCs and *Teians*). It also explored the performance of these two *Kaizen* practices on long-term improvement outcomes. A questionnaire was adopted for data collection and AMOS (Analysis of Moment of Structures) was used to perform Structural Equation Modelling Path Analysis based on 398 responses to a survey conducted in 9 Sino-Japanese automotive joint ventures.

This research was probably the first to study the relationships between the building block shop floor management tools, QCCs and *Teians* using Structural Equation Modelling. The research confirmed their positive relationships. In particular, the frequent use of those building block tools was found to have positive effects on the implementation of both QCCs and *Teians.* Thus, those set of tools was concluded as a powerful aid to provide the basic conditions and framework for *Kaizen*.

Previous research has identified that both QCCs and *Teians* could be used to collect improvement ideas on how to solve immediate problems that were directly related to the individual proposer's working area. This research further identified that the group-based QCCs had a statistically significant and positive impact on improvement outcomes, whereas the advantage of using *Teians* was less obvious. In particular, the individual suggestions through *Teians* had negative effects, which may be attributed to the variation from standard working practices.

However, there was a strong correlation between QCCs and *Teians*, indicating that there was a significant benefit in implementing both practices together. In particular, *Teians* included a mechanism for ensuring that all workers participated, so over the long-term, the *Teians* fostered commitment to the company and Lean practices. Further, *Teians* made an important contribution in identifying and solving shop floor problems on an incremental basis. They provided a background for QCCs in supporting long-term improvements and prevented the results from backsliding to the pre-improvement level. Therefore, QCCs and *Teians* were mutually supportive. The combination of QCCs and *Teians* could go beyond producing one-off improvements or solving problems in the specific work area. They also contributed to future improvement activities through the development of employees' knowledge and skills, and enhanced attitudes. Management, nevertheless, should carefully balance the need for improving participation with the adherence to best practice methods. The objective is to achieve continuous improvement without compromising the rigidity required for standard work.

Acknowledgements

I would like to take this opportunity to express my deep and sincere gratitude to those who helped me a lot to the completion of this research project. So many people and several organisations have directly or indirectly helped and supported me and my work in all aspects during the course of this research. It is therefore difficult to name all them. For those people I am about to omit, I apologise now.

First and foremost, I would like to send great appreciation to my supervisors, Dr. Tom McGovern and Prof. Chris Hicks, for their guidance, suggestions, professionalism, and supervision to set the pace throughout this project; for your expertise to guide me and constructive critiques to challenge my work to get improved continuously; also for your support on providing me a countless number of developmental opportunities, including funding, seminar presentations and research conference attendance. Finally, thank you for cultivating my personal and professional maturation through your mentoring.

To all of the faculty members, staffs, and colleagues, thank you for your help over the years. I particularly want to thank Dr. Robin Humphrey, Dr. Seongming Moon, Dr. Susan Addison, Dr. Yazan Alshamaileh, Dr. Wenbin Xie, Ms June, Ms Oradee, Dr. Arif, Dr. Carlos Osorio, Dr. Rani Shahwan and Dr. Muhammad Siddique for your camaraderie, knowledge and encouragement, both professional and personal, to support me and this research.

I would like to thank all the people who completed the questionnaire. Especially to John Ho, Yong and your friends, thank you for your willingness to share your time, knowledge and professional experience to complete the pilot-testing on the questionnaire. Also, a special thanks to Yunhong Zhong and Uncle Wu for kindly giving me the opportunity to gain access to the case study companies, and the opportunity to meet important personnel.

To my family, especially my parents, Baoming Ma and Shengxin Huang, and uncle Fang and uncle Yuepei Ma, thank you for your support, encouragement and inspiration. To my extended friends: David Thompson, Dr. Chaojie Lee, Dr. Jiayue Wang, Jie Fu, TwoSo, TwoGor, LingLing, CC, Jenifer, Terry, Ping and Lee, thank you for always reminding me that 'nothing is impossible' and instilling in me the confidence to get my dissertation completed. A special thanks to Kejia Mao, for your friendship and constant help that helped me to stay focused throughout the course of this dissertation.

To my fiancée, Yee Ling Cheung, thank you very much for all your support throughout this process. I am honoured to meet you in my life. You just made my dreams come true. I could not have asked for a more beautiful, loving, understanding, strong and positive partner. I am looking very much forward to a happy future with you.

Contents

List of tables

List of figures

Chapter 1 Introduction

1.1 Research Motivation

Since the early 1940s, global manufacturing industry has experienced a shift from the conventional 'buffered' production system (large work-in-progress stocks and inventory) towards Toyota's 'Lean' approach (Womack and Jones, 2005). This 'Lean' approach or 'Lean Production' was originally called the Toyota Production System, or TPS for short (Krafcit, 1988). It was developed by Toyota for the automotive industry (Shingo, 1989). It contains many important tools and techniques (e.g., Feld, 2001; Pavnaskar *et al.*, 2003) to continuously remove waste during the production process to produce final products in an optimal way (Rooney and Rooney, 2005).

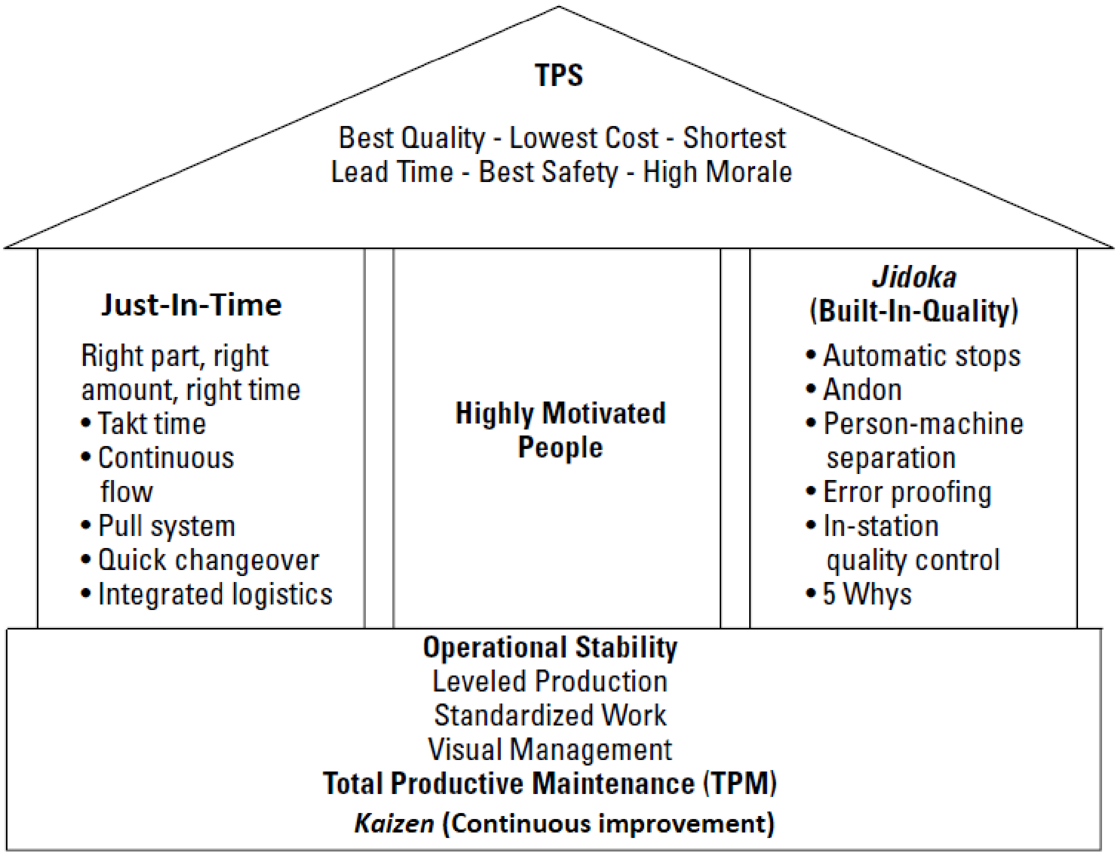


Figure 1.1 The TPS House, a high-level view of the TPS, adopted from Sayer and Williams (2012, p21)

Continuous improvement is one of the key objectives of Lean Production (Handyside, 1997) and is part of the foundations of the 'TPS House' (Watanabe, 2000; Toshiko and Shook, 2007) (Figure 1.1). It has also been increasingly embraced by many companies seeking to improve performance (Prado, 1997; Robinson and Schroeder, 2009) using knowledge of employees (Terziovski and Sohal, 2000). In Japan, continuous improvement is also known as *Kaizen* (改善) (Imai, 1986). Its implementation is driven by a four-step method: the identification of problems; the development of solutions; the implementation of those solutions; and the standardisation of the improved results (Japan Human Relations Association, 1997a).

Although it would appear on the surface simple to implement *Kaizen* as a tool for the functioning of any organisation (Marin-Garcia *et al.*, 2008), it has proved to be easier said than done, and extremely difficult to sustain it in the long-term (Bessant *et al.*, 1994; Bodek, 2004; Veech, 2004; Burch, 2008). In Japan, *Kaizen* is more than a simple improvement system (Brunet and New, 2003; Herron, 2007; Herron and Braiden, 2007). Several studies have reported that many non-Japanese companies (Ghosh and Song, 1991; Sohal and Egglestone, 1994; Oliver *et al.*, 2002; Herron and Hicks, 2008) and some Japanese overseas plants (Aoki, 2008) have experienced difficulties selecting the right methods to enable them to adopt and sustain *Kaizen* for Lean Production. In particular, one study of Japanese and non-Japanese organisations that had implemented *Kaizen* found that the non-Japanese organisations performed comparatively poorly according to various indicators: productivity, quality, changeover time, problem solving, and buyer-supplier relations (Oliver *et al.*, 2002).

Therefore, there is still a gap in terms of adopting and implementing *Kaizen* between Japanese and non-Japanese companies. One of the standard complaints is that many non-Japanese companies and Japanese overseas plants have experienced difficulties selecting the right practices to effectively collect and utilise improvement ideas (Oliver *et al.*, 2002; Aoki, 2008; Herron and Hicks, 2008; Robinson and Schroeder, 2009).

For instance, a number of studies have reported that Japanese companies were able to elicit more improvement ideas from employees (e.g., Yasuda, 1989; Womack *et al.*, 1990; Delbridge *et al.*, 1995; Oliver *et al.*, 1996a; Oliver *et al.*, 1996b; Oliver *et al.*, 1998; Takeda, 2006; Robinson and Schroeder, 2009). The disparities between Japanese and non-Japanese companies was shown to be dramatically high in the late 1990s (Figure 1.2). What is more, this gap was even greater in the automotive industry (Oliver *et al.*, 2002). Japanese automotive companies obtained an average of 28.9 ideas per employee per year, whilst non-Japanese counterparts averaged 2 ideas per year (Oliver *et al.*, 1998).

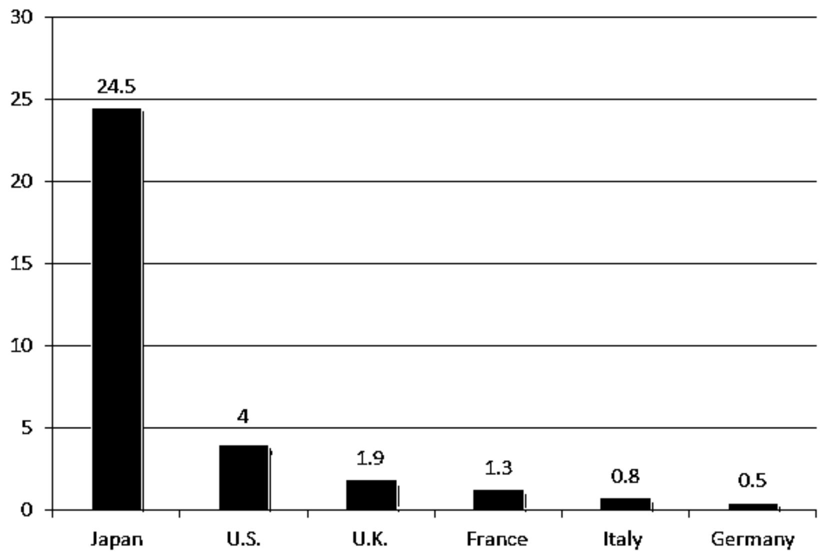


Figure 1.2 Comparative statistics of average *Kaizen* suggestions per employee per year (Oliver *et al.*, 1996b; Oliver *et al.*, 1998; Oliver *et al.*, 2002)

Another major problem is how to implement improvements on a long-term basis (Bessant *et al.*, 2005; Marin-Garcia *et al.*, 2008). Many of the current practices designed for implementing *Kaizen* in non-Japanese companies are universal crash courses (Brunet and New, 2003). They are mainly based on the ideas or proposals of managers, technicians or consultants (Bodek, 2002; Marin-Garcia *et al.*, 2008) rather than involving all members of company (Terziovski and Sohal, 2000); and aimed at producing breakthrough changes and reengineering on a short-term basis (Bessant *et al.*, 2001) through using, e.g., '*Kaizen* blitz' (Sheridan, 1997; Tillinghurst, 1997), '*Kaizen* event' (Doolen *et al.*, 2003), or '*Kaizen* burst' (Liker and Meier, 2006). Thus, These non-gradual methods do not necessarily sustain long-term improvements and achieve long-term targets (Imai, 1986; Dale, 1996; Imai, 1997).

1.2 Research Aims and Objectives

This study aims to bridge the research gap by developing a better understanding of how to implement continuous improvement or *Kaizen* in facilities located outside of Japan. The findings should fulfil the needs of both academics and practitioners in the existing body of knowledge.

The Japanese *Kaizen* is distinctly different from improvement systems that only aim to produce changes by offering monetary rewards (Japan Human Relations Association, 1997a; 1997b; Rapp and Eklund, 2002), or to achieve one-off dramatic innovations (Brunet and New, 2003; Herron, 2007; Herron and Braiden, 2007). Previous research has identified three of the underlying characteristics of *Kaizen*:

- *Kaizen* involves all members of company, and aims to produce small and incremental changes over the long-term (Imai, 1986; Sheridan, 1997; Laraia *et al.*, 1999; McNichols *et al.*, 1999; Bateman and David, 2002);
- *Kaizen* consists of two important practices (QCCs and *Teians*) which are used to collect and implement all sizes of improvement ideas (Onglatco, 1985; Ghosh and Song, 1991; Tamura, 2006; Aoki, 2008; Liker and Hoseus, 2008; Marin-Garcia *et al.*, 2008); and
- *Kaizen* must be based on the support of shop floor management tools, (Malaise, 1995; Handyside, 1997).

This study postulates that there is a strong relationship between the application of shop floor management tools and the performance of *Kaizen*, measured in terms of the number of improvement ideas collected, implemented and the rate of long-term implementation.

The primary purpose of this study was to provide an insight into the implementation of the Japanese *Kaizen* - to increase the understanding of the relationship between shop floor management tools and the two improvement practices (QCCs and *Teians*) and their long-term outcomes. The objectives of this research were:

- *To define the roles of QCCs and Teians in Kaizen;*
- *To describe the implementation of the building block shop floor management tools;*
- *To demonstrate the importance of shop floor management tools in supporting Kaizen;*
- *To explore the relationships between the Kaizen practices, shop floor management tools, and their long-term outcomes;*

- *To provide a better understanding of Kaizen implementation in companies located outside of Japan;*
- *To provide an empirically tested model for studying and managing the Kaizen practices.*

1.3 Research Questions

The research addressed the following questions:

1. What is the Japanese *Kaizen*? How does it differ from other improvement systems?
2. What are QCCs and *Teians*? How do these two practices differ from each other in collecting improvement ideas?
3. What is the relationship between these two *Kaizen* practices? Are they mutually inclusive and supportive of each other? If not, how do they impact on each other?
4. How can the practices of the Japanese *Kaizen* be adopted and implemented to sustain long-term continuous improvement?
5. What are the building block shop floor management tools? In what sequence should they be implemented?
6. In what ways are the shop floor management tools inter-dependent with the *Kaizen* practices? Can they be implemented independently of each other to support the *Kaizen* practices?
7. What is the relationship between these two *Kaizen* practices and their outcomes? How do these practices produce better outcome measures as well as sustaining long-term continuous improvement?

These research questions were addressed by empirical research. Structural equation modelling was used to explore and investigate the relationships between the shop floor management tools, *Kaizen* and their associated outcomes.

1.4 Research Model and Hypotheses

Based on the three underlying characteristics of *Kaizen* (as described in Section 1.2), a theoretical model was developed to support the study. It represents the relationships between shop floor management tools, improvement implementation and improvement outcomes (Figure 1.3).

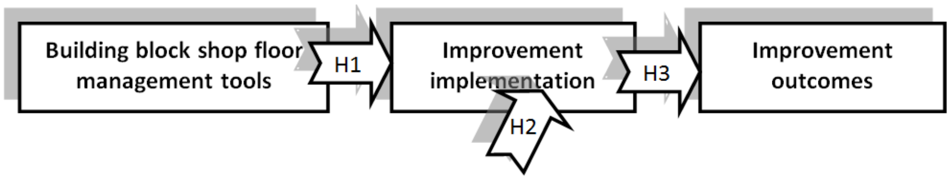


Figure 1.3 The preliminary theoretical model for the current study

Following this model, three hypotheses were investigated:

H1. The building block shop floor management tools have positive effects on the improvement practices.
H2. The two improvement practices are mutually supportive.
H3. The two improvement practices have positive effects on the long-term outcomes.

1.5 The Overview of the Research Method

The study was conducted in Southern China. A survey was employed to collect data from nine Sino-Japanese automotive joint ventures. A questionnaire was developed from previous research (Lillrank and Kano, 1989; Farris, 2006). It included questions that measured: the use of shop floor management tools; the implementation of *Teians* and QCCs; and improvement outcomes. These questions were later translated into Chinese using 'parallel translation' (Saunders *et al.*, 2007, p. p385). They were also piloted with 12 shop floor workers and adapted to suite the Chinese context. In total, 900 copies of the questionnaires were distributed, of which 398 samples were returned, giving a response rate of 44.2%.

After the data collection, Path Analysis (Wright, 1960), a subset of structural equation modelling (SEM) (Kline, 2005), was adopted to develop and analyse the structural path models from the quantitative data. AMOS (Analysis of Moment Structures) (Arbuckle, 2007), a package within the IBM SPSS family (IBM, 2010), was selected to perform these analyses and estimations.

1.6 Outline of the Dissertation

Chapter 2 reviews the different forms of process improvement that have been implemented in the automotive industry. It explains the implementation of the Japanese *Kaizen*, and compares and contrasts *Kaizen* to other improvement practices. It also critically evaluates previous research on the problems, issues and challenges of sustaining continuous improvement.

Chapter 3 introduces Lean shop floor management and highlights its building block tools. In particular, this chapter critically evaluates the relationship between each of these building block tools and their implementation procedures to support and sustain long-term continuous improvement.

Chapter 4 describes the selection of the research sites. It provides a brief historical review of the Chinese automotive industry and automotive joint ventures in Guangdong province. The chapter also describes the case companies and their selection criteria, and shows the development of the theoretical model and the research hypotheses.

Chapter 5 discusses the research design and research methodology. It describes the choice of the survey strategy and the use of SEM for data analysis.

Chapter 6 details data collection procedures, the process of data screening and explains the procedures for examining and validating the reliability of the factor constructs from the data set.

Chapter 7 introduces the use of the SEM path analysis for the hypotheses testing. It details the steps to develop the SEM models, to generate model estimations, and to test the model's reliability. It also lists the results stemming from the final models and the applications of these results to test the hypotheses.

Chapter 8 provides a more detailed analysis and interpretations of the findings. It lists the data obtained from the case companies and evaluates the relationships between the building block shop floor management tools, the two improvement practices and the outcomes.

Chapter 9 outlines the conclusions of the research and provides answers to the research questions. It also lists the limitations of the current study and provides recommendations for future research.

Chapter 2 Process Improvement in Manufacturing Industry

This chapter critically evaluates the existing literature relating to the development of production systems and process improvement in the automotive industry. The chapter is divided into 4 sections: section 2.1 introduces and distinguishes the different types of production systems in the automotive industry, and explains in detail how they were developed and improved over the past century. Section 2.2 defines the Toyota Production System (TPS) and Lean Production, and explores their development. Section 2.3 gives a more precise definition of the Japanese *Kaizen,* distinguishes it from other improvement methods and introduces its two implementing practices, and finally, section 2.4 introduces the different perspectives on comparing the different long-term effects of the two improvement practices and describing their mutual relationship in continuous improvement.

2.1 The Improvement of Production Systems in Manufacturing Industry

"Dissatisfaction is the mother of improvement."

Shingo (1987, p18)

In manufacturing industry, improvement is an enhancement activity to change the performance of a production system from the *status quo* to a new stage (Evans, 1993; Handyside, 1997). In order to meet the new production goals and sharpen competitive advantage, focusing on improvement is becoming more important (Liker, 2004) and therefore it is always required in manufacturing industry (Womack and Jones, 1996). The importance of making improvements in manufacturing industry has also been highlighted by several previous studies (Skinner, 1969; Schonberger, 1982b; Womack *et al.*, 1990; Bartezzaghi, 1999; Fullerton and McWatters, 2001; Pavnaskar *et al.*, 2003; Schonberger, 2006; Colledani *et al.*, 2010).

Achieving constant improvement through small increments is a 'world class' manufacturing practice (Hayes and Wheelwright, 1984) to increase production efficiency (e.g., low cost/high quality) (Womack and Jones, 1996). The improvement of production systems can be a key competitive weapon (Prado, 1997; Hill, 2000, pp., p55; Liker and Meier, 2006). In particular, bringing improvement in all aspects is essential for meeting the production challenges (Bessant and Caffyn, 1997) and a central topic to ensure the competitiveness of the production system (Colledani *et al.*, 2010).

In the automotive industry, production systems have been improved from the Craft Production to Mass Production and during the last few decades to Lean Production (Figure 2.1).

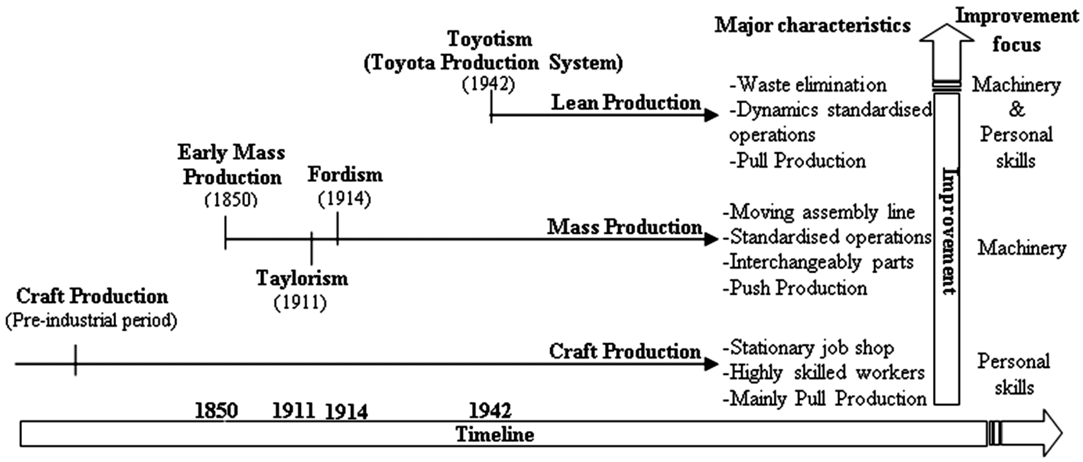


Figure 2.1 The timeline for improvement in the production systems in the automotive industry (Taylor and Brunt, 2001; Clarke, 2005; American Society of Mechanical Engineers, 2008; Patty and Denton, 2010)

2.1.1 The improvement in Craft Production

Before the Mid-1700s, production was small-scale and mainly involved manual work, with or without the aid of tools (Patty and Denton, 2010). This type of production is called Craft Production (Slack *et al.*, 2007). Craft Production is based on a pre-industrialised shop floor production system (Miltenburg, 2005). It is characterised by highly skilled and experienced workers; the use of highly skilled and experienced workers was probably the single most important characteristic at the time (Womack *et al.*, 1990). Thus, improvement was mostly made through apprenticeship training to improve a worker's skills and experience (Clarke, 2005).

Craft Production has the advantage of producing unique, highly customised and flexible products (Womack *et al.*, 1990). However, the use of general-purpose tools, stationary assemblies and extremely decentralised shop floor (Dennis and Shook, 2007) prevented Craft Production from producing high volumes of products quickly (Hobbs, 2004). Especially in the automotive industry, the production of hand-built cars was time-consuming and costly (Ford, 1926). In Europe, before the introduction of Mass

Production, no more than 1000 cars could be built per year, and no two were exactly alike, because each of these cars were built individually and separately to order (Koren, 2010); quality was also inconsistent (Taylor and Brunt, 2001).

Therefore, the main challenges Craft production faced was how to build products at low cost, with consistent quality and at a high speed (Farahani *et al.*, 2011). Just improving workers' skills and experience was not good enough to meet such challenges. Dedicated tools/machines needed to be introduced to boost productivity (Taylor and Brunt, 2001).

Figure 2.2 The Morgan Motor, a modern British craft car producer (The Morgan Motor, 2010)

Craft Production was later replaced by the machine-intensive Mass Production system which could make products in larger volume, more quickly way and with consistent quality (Hobbs, 2004). Modern Craft Production continues to survive (e.g., Figure 2.2), but is generally limited to niche markets for luxury goods (Dennis and Shook, 2007).

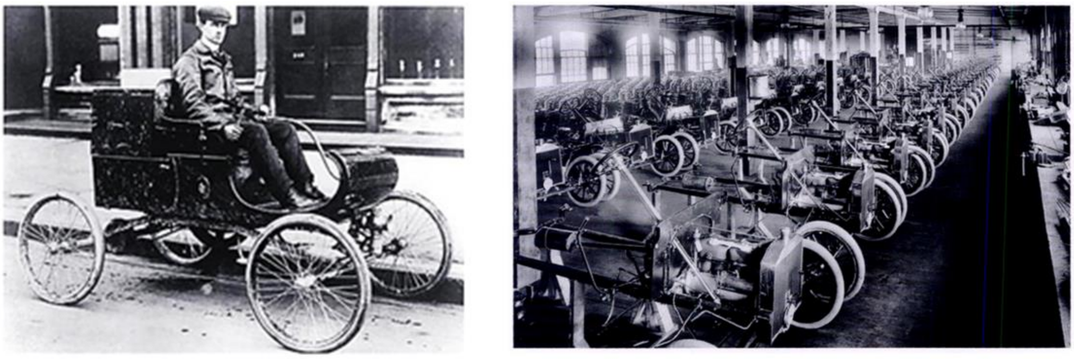
2.1.2 The improvement in Mass Production

Mass Production improved production processes and effectively minimised many of the major problems of Craft Production (Sorensen *et al.*, 2006). It was based on many of Fred Winslow Taylor's (is commonly regarded as the father of scientific management) innovations (i.e., standardised work, reduced cycle time, time and motion study, etc.) from the landmark text: *the Principles of Scientific Management* (Taylor, 1911).

Mass Production separated planning from production and let the shop floor employees do only short cycle, repetitive tasks (Dennis and Shook, 2007). Therefore, in contrast to

Craft Production, Mass Production is a high-quantity production system (APICS Dictionary 9th Edition, 1998). It uses large and dedicated machines and has a continuous flow of materials (Anderson, 1994). It can produce goods in high volume, in a faster manner (Slack *et al.*, 2007) and with significantly lower costs (Hobbs, 2004) than Craft Production (Womack *et al.*, 1990).

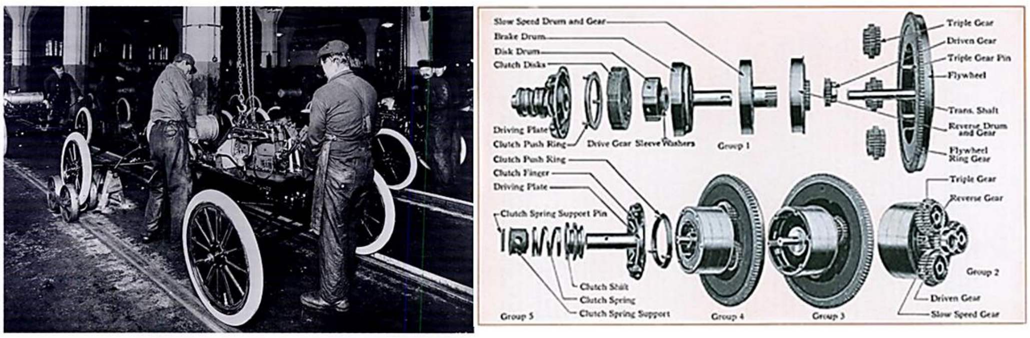
In the automotive industry, the Mass Production system (e.g., Figure 2.3) was introduced at the beginning of the 1900s (Williams *et al.*, 1993). In early 1901, Oldsmobile developed the first high-quantity assembly-line to build cars - the Curved-Dashs (Eckermann and Albrecht, 2001). The assembly-line was however improved substantially by Ford Motors (Patty and Denton, 2010).



(a) (b)

(a) A Curved-Dashs by the Oldsmobile in 1901 (Chevedden and Kowalke, 2012, p20)
(b) Ford's Model-Ns' production brefore the introduction of a moving assembly-line (Cabadas, 2004, p19)

Figure 2.3 The early Mass Production system



(a) (b)

(a) Model-Ts were being produced on a moving assembly-line (Cabadas, 2004, p23)
(b) An example of the standardised parts of the Model-Ts (Collins, 2007, p140)

Figure 2.4 The moving assembly-line and standardised parts

In late 1913, Ford Motors introduced a moving assembly-line at the Highland Park Plant to speed up the production process, and also used interchangeable and standardised components to maintain quality (Ford, 1926, pp., p83) (Figure 2.4). By 1915, the Highland Park Plant produced around 500,000 Model-Ts per year (Nersesian, 2000, p. p50). Later, the production line made a total number of 15 million Model-Ts in 19 years (1908-1927); on average approximately 800,000 per year (Williams *et al.*, 1993; Sorensen *et al.*, 2006). The use of the moving assembly-line and standardised components became the basis of contemporary automotive production (Ohno, 1988a, pp., p93). Womack et al. (1990) complemented Ford's development of the moving assembly production line and the use of standardised interchangeable components, saying they were some of the great achievements of the automotive industry.

However, Mass Production also has major short-comings. *Firstly*, the use of dedicated machinery eventually resulted in a significant drop in the average skill level of the workforce, as many skills were made redundant by the machinery (Encyclopaedia Britannica, 1998; Koren, 2010). Therefore, skilled workers became less important, and the improvements achieved by Mass Production were mainly derived from the use of more efficient machinery (Dennis and Shook, 2007, p. p2).

Secondly, most Mass Production machines were large, only served a single-purpose and were very expensive to purchase (Womack *et al.*, 1990). As Bowden and Higgins (2004, p386) argued, "Fordist production methods were characterised by the use of high cost, specially designed machines… [Thus,] the end result was high volume production of standardised products". Compared to Craft Production, the investment costs of Mass Production had increased dramatically.

Thirdly, most of these Mass Production machines were expensive to run (Womack *et al.*, 1990), which resulted in complexity on the shop floor (Jones, 2001). The Mass Production machines "…relied on a seemingly endless supply of natural resources, such as ore, timber, water, grain, cattle, coal, [and] land…" (Clark and Brody, 2009, p465) (Figure 2.5). It needed "…expensive and complicated forecasting, planning, scheduling and supplier coordination…" to keep the machines running (Jones, 2001, p19). For instance, Ford used to produce everything for the Model-Ts by using a vertically integrated system on its highly centralised shop floor, "…[this] operation extended from the iron ore mines all the way to the finished product" (Murman *et al.*, 2002, p88). Accordingly, as Henry Ford (1926, p82) recalled, "our organization, [Ford's Highland

Park Plant], has not enough [resources/spaces] to make two kinds of motor car under the same roof".

In about 1928, showing iron ore carriers in the northern end of the slip at the right and storage bins at the left of the slip. Further left are the blast furances, foundry, and power plant.
Figure 2.5 The Rouge plant, world's largest single-company industrial concentration (Lewis, 1987, p172)

Fourthly, most of those Mass Production machines were only built for a single-purpose. The reason being that the changeover time of these machines was very long (Batchelor, 1994). As Miozzo and Walsh (2006) commented, the long changeover time was even treated as a fixed constraint. Therefore, machines were only used to make one type of product at a time to avoid the necessity of changeover (Womack *et al.*, 1990). Thus, low product variety was another main characteristic of Mass Production (Kamrani and Nasr, 2008, p. p228). For instance, Ford used to only mass-produce black Model-Ts in its Highland Park Plant (Leseure, 2002) (Figure 2.6).

On an assembly-line, every car was made with exactly the same parts. Each car was not made special or different
Figure 2.6 The black Model-Ts (Rausch, 2007, p18)

Thus, *fifthly*, in order to maximise the use of the expensive machines, most mass-produced products were made-to-stock, which increased costs (Slack *et al.*, 2007). For example, with the purpose of taking benefits from the large economies of scale and scope (Hobbs, 2004), Ford mass-produced its cars to meet the needs of the vast market in the 20th Century, but it ended up with massive waste in overproduction (Whaples and Betts, 1995; Murman *et al.*, 2002, pp., p88; Datta, 2004).

Therefore, the drawbacks of Mass Production highlighted the necessity for improvements which could achieve an appropriate balance between machines and workforce skills. What was required was a more cost-effective production system which had the flexibility to produce a wide variety of products, with high quality, at low cost (Ohno, 1988a, pp., xiii).

2.1.3 The improvement in Lean Production

The latest production system, the Toyota Production System (or later Lean Production, coined by Krafcit, 1988), was being developed in Japan from the 1940s (Murman *et al.*, 2002; Hobbs, 2004; Toshiko and Shook, 2007). It was originally used to make products to meet the Japanese small-lot production pattern (Ohno, 1988a) and "was a direct challenge to the older paradigms" (Lillrank, 1995, p973).

Lean Production "combines the advantages of Craft Production and Mass Production" (Womack *et al.*, 1990, p13) and is considered to be another revolution in productivity in manufacturing industry (Slack *et al.*, 2001; Holweg, 2007). Lean Production has the ability to achieve machine and workforce improvements (Shingo and Bodek, 1988; Yoneyama, 2007; Takeuchi *et al.*, 2008). It mainly relies on a multi-skilled and highly experienced workforce to improve machinery to make a variety of products at high speed, with high quality, and most importantly, reducing the waste of overproduction (Denton, 1995).

Lean Production "offers significant advantages over other [production] methods, dramatic improvements in productivity and quality that no other system can match" (Scarbrough and Terry, 1998, p224). Lean Production has therefore, gained wide recognition for the advantages that it offers compared to Mass Production and Craft

Production (Salvendy, 2001; Bicheno, 2004). The following Table 2.1 summarises the characteristics of the three types of production systems.

	Craft Production	**Mass Production**	**Lean Production**
Focus	Task	Product, Result	Customer, Process
Skill level	High skilled	Low skilled	Multi-skilled
Overall aim	Mastery of craft	Reduce cost and increase efficiency	Eliminate waste and add value
Operations	Single items	Batch and queue	Synchronised flow and pull
Tools required	General purpose	Dedicated	General purpose
Teamwork	Moderate	Low	High
Production plan	Make-to-order	Made-to-stock Plan-push	Made-to-order Demand-pull
Defect rate	Various	High	Low
Quality check	Integration (part of the craft)	Inspection (a second stage, after production)	Prevention (built in by design and methods)
Warehouse size	No / very small	Very large	No / small
Buffers	Large	Large	No / very small
Production Volume	High variety low quantity	Low variety high quantity	High variety high quantity
Business strategy	Customisation	Economies of scale and automation	Flexibility and adaptability
Improvement	Master-driven continuous improvement	Expert-, result-driven periodic improvement	Workforce-, process-driven continuous improvement

Table 2.1 The characteristic comparison of each production system in the automotive industry (Krafcit, 1988; Womack *et al.*, 1990; Evans, 1993; Taylor and Brunt, 2001; Murman *et al.*, 2002)

2.2 Lean Production

Lean Production is derived mostly from Toyota which is widely known as the Toyota Production System (TPS) (Emiliani, 2006). It is implemented in the automotive industry (Shingo, 1989) to achieve 'Lean' in everything (Krafcit, 1989) with an "absolute minimum" use of warehouse for storage, "bufferless assembly lines", "utility workers" and a "tiny" repair area (Krafcit, 1988, p45).

2.2.1 The definition of Lean Production

The term Lean Production was initially adopted by the International Motor Vehicle programme (IMVP) in 1979 (Krafcit, 1988; Womack *et al.*, 1990). The IMVP is one of the oldest and largest international research consortiums from the Massachusetts Institute of Technology (MIT) that aimed to understand the challenges facing the global automotive industry (Krafcit, 1988; Lewis, 2000; IMVP, 2008). In the late 1980s, the IMVP published two landmark books in this field: *The Machine that Changed the World* (Womack *et al.*, 1990) and *Lean Thinking* (Womack and Jones, 1996) to compare the automotive industry in Japan and the West.

Over the years, the term 'Lean Production' or just 'Lean' has become more widely cited and it has been defined differently (Lewis, 2000; Shah and Ward, 2007):

> *"[Lean Production] means moving towards the elimination of all waste in order to develop an operation that is faster, more dependable, produces higher-quality products and services and, above all, operates at low cost" (Slack et al., 2007, p466).*

Others have defined Lean Production with a focus on its philosophy of production:

> *"[Lean Production is] a philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and dealing with the customers." (APICS Dictionary 9th Edition, 1998, p49)*

The current study adopted the definitions of Lean Production which emphasised continuous improvement and the elimination of waste. Krafcit (1988), a researcher in MIT for the IMVP programme, put forward the following definition:

> *"This [TPS] plant has been in the midst of a sustained, corporate-led drive to continuously improve its efficiency, to reduce costs in every facet of the operation, and to relentlessly improve quality." (Krafcit, 1988, p41)*

The definition given by Handyside (1997) in a major study of Lean Manufacturing shop floor:

> *"True lean manufacturing is simply concerned with the constant and never-ending elimination of waste" (Handyside, 1997, p163).*

And a more recent definition given by Radnor et al. (2012):

> *"Lean as a management practice based on the philosophy of continuously improving processes by either increasing customer value or reducing non-value adding activities (muda), process variation (mura), and poor work conditions (muri)"(Radnor et al., 2012, p365).*

2.2.2 The development of Lean Production

Lean Production originated in Japan and was developed initially in the automotive industry (Womack *et al.*, 1990; Womack and Jones, 1996; Jones, 2001). It was especially, pioneered and exemplified by Toyota (Hines *et al.*, 2004), so it has been given the name: Toyota Production System (or TPS) (Shingo, 1990; Toyota, 1995).

The TPS remained unknown outside Toyota until the late 1970s, as it was never intended for adoption beyond Toyota in the first place (Schonberger, 1982b; Emiliani, 2006; Schonberger, 2006). Bodek (2004, p28) indicated that "the Toyota Production System had given Toyota a great competitive advantage and they did not want to share this information with other automotive companies". This was supported by Sako (2004) who indicated that the TPS was kept as a secret within Toyota until they decided to share it with their suppliers in the 1970s. Schonberger (1982b) also revealed that only a few journal articles described the TPS in the late 1970s. Especially in the West, no English paper was published that mentioned the TPS or JIT until 1977 (i.e., Ashburn, 1977; Sugimori *et al.*, 1977). Taylor and Brunt (2001, p20) reinforced the point and reported that "in the early 1970s, the TPS was documented for the first time, though it took another decade before these principles were published in books and articles".

In the early 1980s, many Western academics begun studying Toyota's success and taking note of the benefits of their seemingly revolutionary production system (e.g., Hayes, 1981; Schonberger, 1982a; Schonberger, 1982b; Schonberger and Gilbert, 1983; Cusumano, 1988). In particular, according to The Asian Productivity Organization (2013), two of these academics were James Womack of the MIT and Daniel Jones of the University of Cardiff in Wales. It was these authors who were widely credited for adopting the term 'Lean Manufacturing/Lean Production' from Krafcit (1988) to describe the TPS to the West (Womack *et al.*, 1990; Womack and Jones, 1996).

In the 1990s, the landmark book *The Machine that Changed the World* was published (Womack *et al.*, 1990). It adopted the term 'Lean Manufacturing/Lean Production' to describe the TPS (Krafcit, 1988; Engström *et al.*, 1996; Fujimoto and Takeishi, 2001). This book combined disparate Lean principles together and introduced them in a systematic fashion (Karlsson and Ahlstrom, 1996). Today, describing the TPS as Lean Production is widely accepted and both names have been used interchangeably in many recent publications (e.g., Okino, 1995; Rinehart *et al.*, 1997; Fujimoto and Takeishi, 2001; Liker, 2004; Liker and Meier, 2006; Schonberger, 2006; Dennis and Shook, 2007; Pil and Fujimoto, 2007).

2.2.3 The philosophy of Lean Production

Lean Production is also a management philosophy (Womack *et al.*, 1990; Womack and Jones, 1996; Bicheno, 2004). "Lean Production is 'Lean' because it uses less of everything compared with Mass Production - half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new production in half the time" (Womack *et al.*, 1990, p13).

Manufacturing Flow
1. Product/quantity assessment (product group)
2. Process mapping
3. Routing analysis (process, work, content, volume)
4. Takt calculations
5. Workload balancing
6. Kanban sizing
7. Cell layout
8. Standard work
9. One-piece flow

Process Control
1. Total productive maintenance
2. Poka-yoke
3. SMED
4. Graphical work instructions
5. Visual control
6. Continuous improvement
7. Line stop
8. SPC
9. 5S housekeeping

Metrics
1. On-time delivery
2. Process lead-time
3. Total cost
4. Quality yield
5. Inventory (turns)
6. Space utilization
7. Travel distance
8. Productivity

Organization
1. Product-focused, multi-disciplined team
2. Lean manager development
3. Touch labor cross-training skill matrix
4. Training (lean awareness, cell control, metrics, SPC, continuous improvement)
5. Communication plan
6. Roles and responsibility

Logistics
1. Forward plan
2. Mix-model manufacturing
3. Level loading
4. Workable work
5. Kanban pull signal
6. A,B,C parts handling
7. Service cell agreements
8. Customer/supplier alignment
9. Operational rules

Figure 2.7 The different Lean tools and techniques, adopted from Feld (2001, p5)

Lean Production consists of many tools and techniques for minimising the amount of all resources used in various activities (Fujimoto and Takeishi, 2001; Scaffede, 2002; Pavnaskar *et al.*, 2003; Shah and Ward, 2003; Liker, 2004; Morgan and Liker, 2006) (e.g., Figure 2.7). They include product design (e.g., product design for simplification and error-proofing) (Shingo, 1986; Gotō and Odagiri, 1997) and manufacturing (e.g., automation with human touch and single-minute exchange of die) (Shingo and Dillon, 1985), supply chain management (e.g., just-in-time delivery) (Turnbull *et al.*, 1989; Turnbull *et al.*, 1992; Sako, 2004), shop floor management/continuous improvement (e.g., 5S practice, visual management, *Kaizen*, etc.) (Handyside, 1997; Imai, 1997), customer and supplier focus (e.g., quality mapping to increase customer value, modular sourcing, supplier association, supplier collaborations, etc.) (Hines and Rich, 1997; Howard, 2005; Schonberger, 2006), and employing multi-skilled workers and cross-functional teams (Morris *et al.*, 1998; Delbridge *et al.*, 2000).

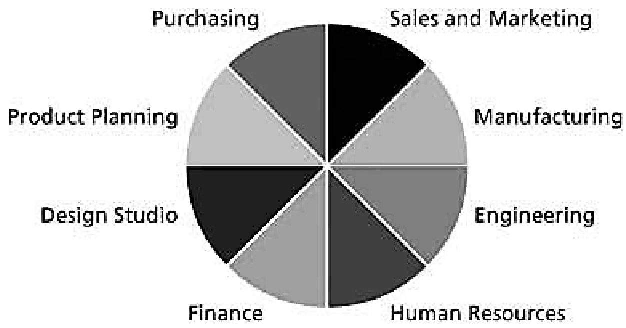


Figure 2.8 The eight disciplines of the Lean enterprise model (Morgan and Liker, 2006)

These tools and techniques can be further divided into 8 disciplines (Figure 2.8) and classified accordingly into four main categories to build a Lean Production organisation (Peters, 1989; Salvendy, 2001). Ahlstrom and Karlsson (1996) concluded these findings and developed the following conceptualisation to show the major compositions of a Lean Production organisation (Figure 2.9).

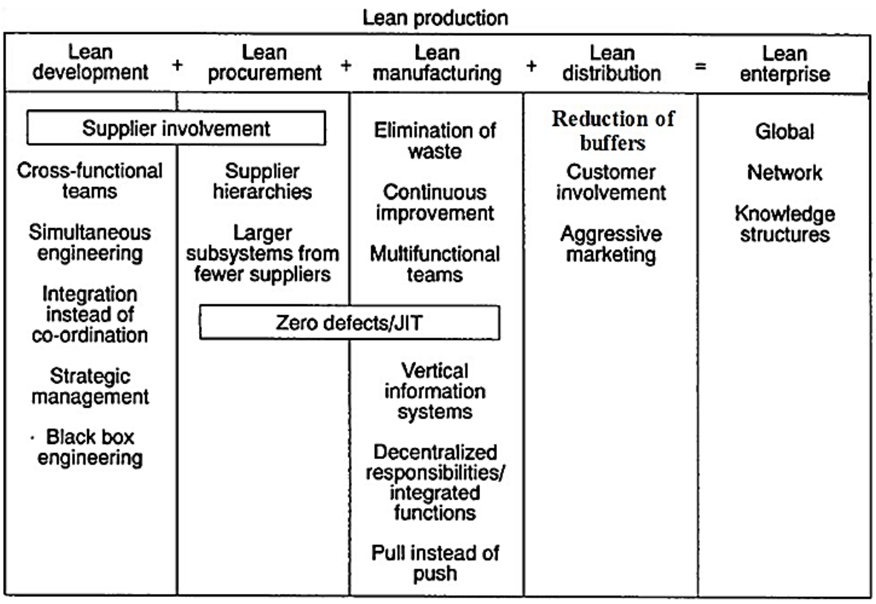


Figure 2.9 The conceptualisation of Lean Production (Karlsson and Ahlstrom, 1996, p26)

2.3 Continuous Improvement in Lean Production

As a successor to Craft Production and Mass Production, Lean Production has been improved significantly to have many small and simple manufacturing machines but multi-skill and experienced workforce (Womack *et al.*, 1990). Yet, in manufacturing industry, having many machines and a skilled workforce does not make an outstanding production system. According to many previous studies (e.g., Kono, 1982; Bessant *et al.*, 1994, pp., p18; Bhuiyan and Baghel, 2005), what made Lean Production better than the previous systems was the core feature of achieving continuous improvement. As

Womack et al. (1990) argued, the implementation of continuous improvement is one of the core features of Lean Production for striving towards perfection.

Continuous improvement has always been noted as a powerful tool for maintaining the competitiveness of organisations through Lean Production and one of the foundations that support the implementation of other Lean tools and techniques (Toshiko and Shook, 2007). Ahlstrom (1998, p331) revealed that “the final Lean Production principle is continuous improvement: perfection is the only goal”. Liker and Hoseus (2008, p63) indicated that “without continuous improvement the tools of Lean Production would be useless”. Imai (1986, pxxxii) even argued that continuous improvement is “the unifying thread running through the philosophy, the systems, and the problem-solving tools developed in Japan over the last 30 years”.

Continuous improvement is defined as “a continual quest to make things better in products, processes, customer service, etc.” (Bessant and Caffyn, 1997, p7). It involves company-wide (Bodek, 2002), high frequency changes (Chartered Quality Institute, 2011) and it is synonymous with ‘innovation’ (Bessant *et al.*, 1994; De Jager *et al.*, 2004). Continuous improvement does not necessarily require large capital investments (Imai, 1986; Imai, 1997; Terziovski and Sohal, 2000) and is not always based on advanced methodologies (Rapp and Eklund, 2002), it seldom results in a big leap or generates a dramatic change (Bhuiyan and Baghel, 2005).

2.3.1 The origins of continuous improvement

Continuous improvement is commonly cited as one of the key methods of Lean Production (Lillrank, 1995) and a correction to Taylorism (Tamura, 2006). It was derived from a unique Japanese culture (Recht and Wilderom, 1998; Yoneyama, 2007; Liker and Hoseus, 2008) that permeates the mindset and behaviour of the Japanese from an early age (De Mente, 1976). Accordingly, the uniqueness of these characteristics may have handicapped non-Japanese companies seeking to implement continuous improvement (Onglatco, 1985).

However, it has been argued that the antecedents of continuous improvement did not originate in Japan, nor is it a new Japanese phenomenon. This proposition was also identified in many studies (e.g., Kono, 1982; Imai, 1986; Cusumano, 1988; Schroeder and Robinson, 1991; Bessant *et al.*, 1993; Recht and Wilderom, 1998; Dinero, 2005; Holweg, 2007), in which the authors argued that continuous improvement was not peculiar to the Japanese. Many Western organisations were indeed the forerunners of the modern improvement programme (e.g., incentive-driven suggestion systems in the West), as their implementations can be traced back to the 1800s (Bhuiyan and Baghel, 2005), or much earlier (Holweg, 2007).

Some early examples include for employee suggestion programme in the British Navy in 1770 (Graban and Swartz, 2012); the awards scheme for improvement in William Denny & Brothers, a Scottish shipbuilding company, in 1890 (Schwerin, 2004); the implementation of a suggestion-box improvement programme in the US National Cash Register Corporation in 1894 (Bessant *et al.*, 1993); the idea of making improvements from the 'hundred-headed brain' from the well-known American company Lincoln Electric (Schroeder and Robinson, 1991); and later Henry Ford's insistence on making improvement in Ford's Highland Park Plant (Ford, 1926). In addition, the early examples of quality control activities also proceeded rapidly in the West, illustrated by the development of the British Standard BS 600 for quality control in 1935 (Morrision, 1958); the American equivalent - America's Z1 Standards – Guide for Quality Control in 1941 (Ishikawa, 1990); and the establishment of the American Society for Quality Control (ASQC or ASQ) in 1946 (American Society for Quality, 2012).

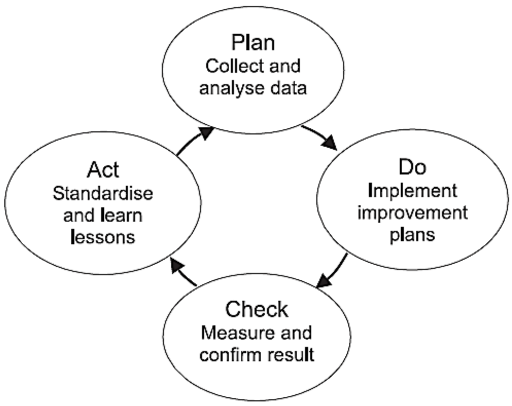


Figure 2.10 The PDCA Cycle (Deming, 1986)

Meanwhile, the famous Shewhart Cycle or the Plan Do Check Act (PDCA) Cycle (Figure 2.10), as a critical model and a major practice of improvement (Bakerjian and Mitchell, 1993), was originally developed by Walter Shewhart, an American physicist, engineer and statistician, in the 1930s (Shewhart, 1931). It was promoted within manufacturing industry (Shewhart, 1986) and became a well-established approach as a consequence of William Deming's publications (e.g., Deming, 1950; Deming, 1982; Deming, 1986). This four-step process has now been widely adopted for problem-solving and formed the basis of Japanese continuous improvement (Bessant *et al.*, 1994; Choi, 1995; Handyside, 1997, pp., p126-127; Bond, 1999; Watson *et al.*, 2003) (Figure 2.11).

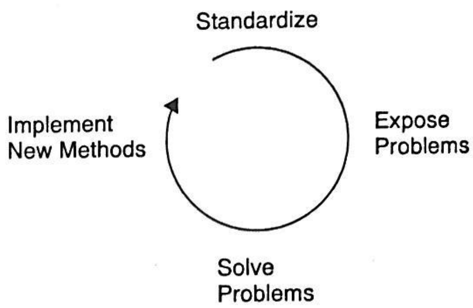


Figure 2.11 The cycle of Japanese continuous improvement (Suzaki, 1993, p96)

The Western improvement methods were introduced into Japan from the early 1900s (Saha, 1994; Choi and Liker, 1995; Recht and Wilderom, 1998). In particular, after the Second World War in 1945, the Americans assisted Japan in rebuilding its economy (Schroeder and Robinson, 1991), through support for economic reforms and industrial development (Poropat and Kellett, 2009). The Economics and Scientific Section (ESS) group was formed to develop Japanese management skills (Iguchi, 2003). The three Training within Industry (TWI) "J" programmes taught Job Instruction, Job Methods, and Job Relations (Dinero, 2005). The Japanese Union of Scientists and Engineers (JUSE) introduced continuous improvement programmes (Ishikawa, 1990) based upon the best improvement methods from the West (Deming, 1950; Crocker *et al.*, 1984; Inoue, 1985). The improvement methods then became an imperative to support the development of Japanese manufacturing industry (Saha, 1994).

The use of the improvement methods in Japan grew rapidly with the aid of Western management experts (e.g., Gilbreth and Carey, 1948; Deming, 1986; Juran, 1988). Poe (1991) argued that the development of continuous improvement programmes were based on Japanese managers' interpretations of the Western manufacturing philosophies. Japanese managers claimed to be responsive to new methods and ideas (Kono, 1982). They were quick to respond to foreign ideas and to implement them by conducting new development research. For instance, in the 1950s, many early exemplary companies like Toshiba, Matsushita Electric, NEC, Canon and Toyota developed their own branded improvement programmes to include both suggestion schemes and quality control circles (Cusumano, 1988; Schroeder and Robinson, 1991). Over the following twenty years, Japan became prominent in implementing continuous improvement (Schonberger, 1982a, pp., p52). They “set new standards of efficiency and started a revolution in manufacturing industry…” (Cusumano, 1988, p38). Therefore, the Japanese continuous improvement programme has a different pathway from the Western improvement programmes (Suzaki, 1993; Bartezzaghi, 1999; GRIPS, 2009) and includes some unique characteristics (i.e., continuous changes in small increments; based on two improvement practices; and requirement of shop floor management tools) (Ishikawa, 1980; Yasuda, 1989). The improvement programme plays an important role in Japanese economic development (Inoue, 1985), and has a Japanese name *Kaizen* (Imai, 1986).

2.3.2 The implementation of Japanese Kaizen

The Japanese are renowned for implementing *Kaizen* (Schonberger, 1982a, pp., p52). This has helped Japanese manufacturing industry to achieve a high level of competitiveness over the past few decades (Hayes, 1981; Tamura, 2006; Aoki, 2008).

The traditional Western improvement programmes	**The Japanese *Kaizen***
Develop and implement by different people	Proposals developed and implemented by the same people
Management-led top-down process	Management can either make suggestions individually or as a member of a QCC group
One-off changes	Incremental process
No clearly defined tools	Based on PDCA cycle and statistical tools
Emphasis on suggestions for large improvements	Focus on ideas various sizes of problems
Financial reward for proposers based upon improvement outcomes	Small financial reward mainly based on participation
Management approval needed before implementation	Management approval only needed for large improvement
Management assessment is often delayed due to periodic review processes	Reviewed frequently in a timely manner

Table 2.2 Differences between the traditional Western improvement programmes and the Japanese *Kaizen*

The implementation of the Japanese *Kaizen* is different (Table 2.2) from its implementation in the West (Imai, 1986; Berger, 1997; Kerrin, 1999; Nilsson-Witell *et al.*, 2005). Western improvement programmes generally emphasise improvement ideas for ‘one-off’ changes (Peter, 1990; Recht and Wilderom, 1998). They are management-led and top-down implementations (Graban and Swartz, 2012). The focus is usually on large improvements which are often not implemented by the proposers (Nihon HR Kyōkai, 1995). The financial incentives are used to stimulate the participation (Yasuda, 1989), but they are commonly associated with the final improvement outcomes (Imai, 1986). The Western improvement programmes may suffer from low participation and low acceptance rates (Hull *et al.*, 1988).

The Japanese *Kaizen*, on the other hand, is a “never ending” (Bond, 1999, p320), with a “top-down…and…bottom-up” framework (Bessant and Francis, 1999, p1109), “on-going improvement” (Imai, 1986, p3) “of a cumulative character” (Marin-Garcia *et al.*, 2008, p57). It instils in everyone within the organisation (Peter, 1990; Terziovski and Sohal, 2000) a sense of responsibility for implementing improvements on a continuous basis (Monden, 1983), such as habitually providing both personal suggestions (Imai, 1986; Imai, 1997) and implementing group-based improvement activities (Handyside, 1997). Therefore, Japanese *Kaizen* is “not of the breakthrough variety, but incremental in nature” (Bessant and Caffyn, 1997, p10). It is “an organisational-wide process of focused and sustained incremental innovation” (Bessant and Francis, 1999, p1106); or “a habitual way of life in the organisation” (Handyside, 1997, p14) to develop both small and large improvement ideas. Management approval is only needed for large improvement ideas, whilst small changes can be implemented without the prior approval of management (Crocker *et al.*, 1984). Financial rewards are also used to boost participation (Imai, 1986; Kerrin, 1999).

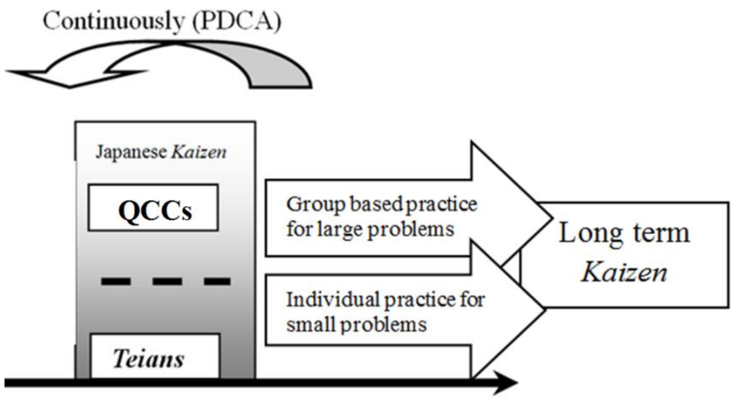


Figure 2.12 The Japanese *Kaizen*, developed from the Japanese Human Relations Association (1997a)

According to the Japanese Human Relations Association (1997a), the implementation of Japanese *Kaizen* (Figure 2.12) includes two different improvement practices and is driven by a simple four-step (PDCA) method: (1) the identification of problems; (2) the development of good solutions; (3) the implementation of those solutions; and (4) the standardisation of the improved results and prepare for future improvement (Recht and Wilderom, 1998; Masaki, 2006; Kupanhy, 2007; Toshiko and Shook, 2007).

The two practices are Quality Control Circle programmes (QCCs, group-based improvement programmes, QC 小組活動) (Ishikawa, 1980; Crocker *et al.*, 1984; Ishikawa, 1985a; Suzaki, 1993) and *Teians* (Japanese for personal improvement suggestions/proposals, 提案) (Yasuda, 1989; Nihon HR Kyōkai, 1995). They both can be employed to utilise improvement ideas (Marin-Garcia *et al.*, 2008) for identifying, investigating, analysing and solving work-related problems (Kono, 1982; Charantimath, 2003).

2.3.3 The differences between the two improvement practices

However, according to previous research, the approach adopted for implementing these two practices is different in many ways. QCCs (or just QCs) comprise group-based activities that include a small number of volunteer employees. The group is small enough to allow face-to-face communication (Lillrank and Kano, 1989), i.e., between 5 to 15 members (Ma *et al.*, 2010). They meet regularly (e.g., once per week) (Greenbaum *et al.*, 1988; Lillrank and Kano, 1989; Sillince *et al.*, 1996; Bacdayan, 2001) to share ideas and expertise for improvement (e.g., quality or costs of manufacture, and health and safety of shop floor) (Terziovski and Sohal, 2000; Charantimath, 2003, pp., p293). They rely on cross-functional team (Bessant *et al.*, 1994), support from line supervisors and top management (Prado, 2001; Milakovich, 2006) and focus on group decisions to develop improvement themes with specific and measurable goals (Landsbergis and Cahill, 1999; Doolen *et al.*, 2008). In contrast, *Teians* offer a procedure for collecting and evaluating individual personal suggestions (Akaoka, 1983; Neagoe and Marascu_Klein, 2009). They are based on individuals' willingness to make implementable (hands-on) improvement ideas (van Dijk and van Den Ende, 2002) which involves the completion of a *Teian* sheets (i.e., paper-based or electronic, Japan Human Relations Association, 1997a; Schuring and Luijten, 2001).

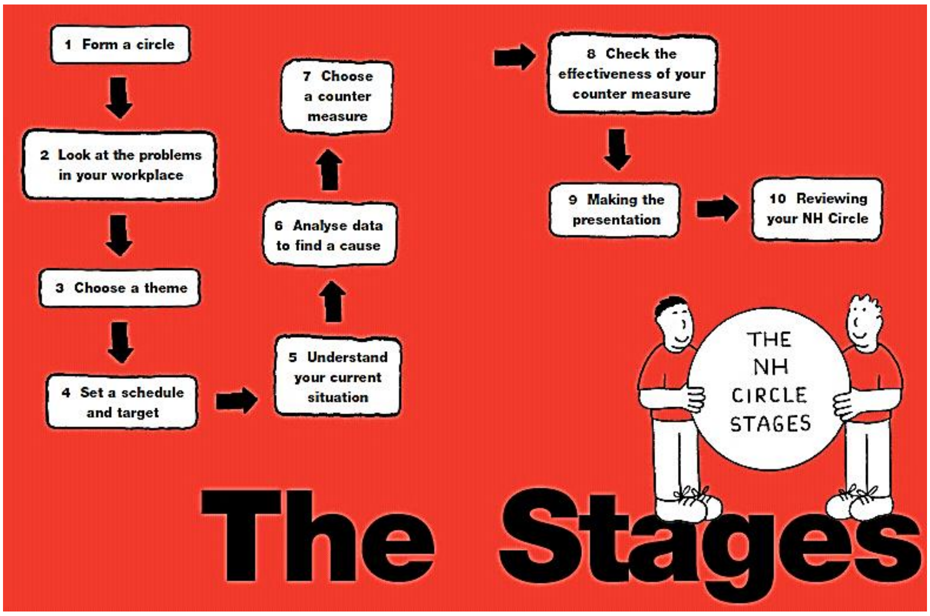


Figure 2.13 A QC story by Honda Motor Europe (1998, p14-15)

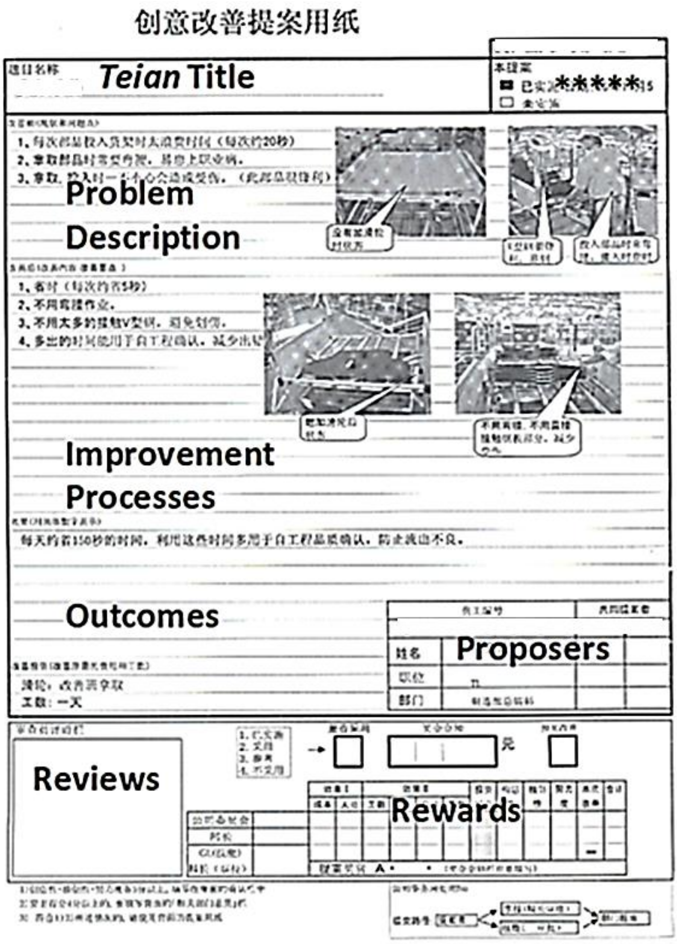


Figure 2.14 An example of a *Teian* Sheet from one of the case company archives

QCCs develop improvement plans that are approved by management. They must follow an implementation procedure or standard pattern approach (i.e., QC story or QCC guide book) (Figure 2.13) (Akaoka, 1983; Inoue, 1985; Ho, 1999, pp., p161; Farris, 2006). Whereas *Teians* collect personal improvement sheets which relate to previously implemented solutions and outcomes (Figure 2.14) (Akaoka, 1983; Nihon HR Kyōkai, 1995).

Although both QCCs and *Teians* can be employed for producing work-related improvements, they have different scale. QCCs are formal improvement bodies (Lillrank and Kano, 1989) and mainly implement improvement on a department-wide/company-wide basis (Inoue, 1985; Terziovski and Sohal, 2000; Harrington, 2006), as these changes are part of/linked with the company's long-term total quality control activities (Ishikawa, 1990; Charantimath, 2003). Some of the QCC themes are designed for problem solving (i.e., improving the quality of goods), others are intended to make innovative changes to shop floor/workplaces on a continuous basis (i.e., to introduce new machinery or production techniques to increase productivity) (Ishikawa, 1990; Milakovich, 2006). On the other hand, *Teians* are intended to resolve local problems within the proposers' immediate working area (i.e., production shop floor) (Nihon HR Kyōkai, 1995, pp., p5). Most of these problems are small-scale and thus any improvement made is simple (Marin-Garcia *et al.*, 2008) and commonly based on hands-on knowledge (Yasuda, 1989).

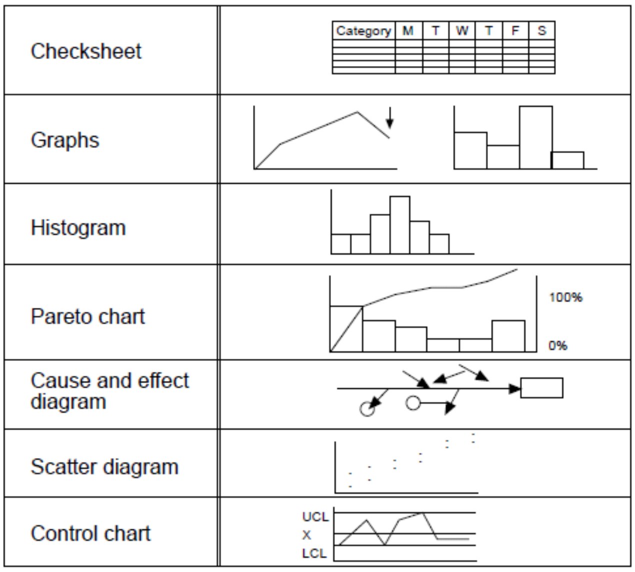


Figure 2.15 Ishikawa's 7 QC Tools, adopted from Pescod (1994, p12)

The different degrees of change, thus, require different knowledge and skills for implementation. The group-based QCCs require members to have a good knowledge of improvement (Toshiko and Shook, 2007) and use Ishikawa's QC statistical tools (Figure 2.15) for the development of the improvement themes (Ishikawa, 1980; JUSE, 2010), whilst *Teians* are highly dependent on participants' shop floor experience and production skills.

QCCs and *Teians* also differ in their implementation time-frames. Although the implementation follows Deming's PDCA cycle continuously (Figure 2.16), most of the QCC projects have defined time limits (Harrington, 2006, pp., p14). They have pre-set targets and expected outcomes (Ishikawa, 1990; Terziovski and Sohal, 2000), and aim to be finished within predetermined duration (Kerrin and Oliver, 2002; Rapp and Eklund, 2002); e.g., 6 months, or no more than a year (Honda Motor, 1998), as a new QCC project will probably need to be started afterwards (Ma *et al.*, 2010). More importantly, the end result of a QCC is not an actual improvement, but an action plan for change which is then presented to management for approval (Crocker *et al.*, 1984; Cohen and Bailey, 1997). The *Teians*, in contrast to QCCs, are normally applied immediately to make gradual changes. Only after that the change details are recorded for evaluation. Each of the changes may be small, but they can be exceptionally well managed (Rapp and Eklund, 2002) and implemented on a continuous basis (Nihon HR Kyōkai, 1995).

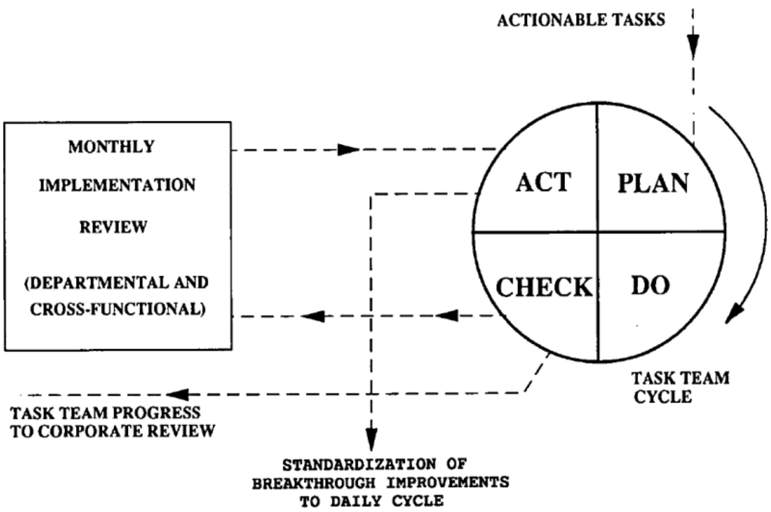


Figure 2.16 Team-based improvement (e.g., QCC) implementation follows Deming's PDCA cycle continuously (Wood and Munshi, 1991, p220)

QCCs and *Teians* use different reward methods to motivate participation (Recht and Wilderom, 1998; Kerrin and Oliver, 2002; Milakovich, 2006) (Table 2.3), and are evaluated differently by a committee of mangers (Yasuda, 1989; Frese *et al.*, 1999). On the one hand, rewards for *Teians* are based on improvement participation (Nihon HR Kyōkai, 1995; Fairbank and Williams, 2001). A *Teian* suggestion is based upon improvements that record what has been done on the proposers' (Imai, 1986; Tamura, 2006) "immediate work area" (Nihon HR Kyōkai, 1995, p5). Accordingly, the emphasis of *Teians* should be on "proposing ideas that workers could implement themselves", not just "suggesting for improvement" (Nihon HR Kyōkai, 1995, p18), as "*Kaizen* [*Teians*] is doing, not proposing [suggestions]" (Laraia *et al.*, 1999, p6). In this sense, rewards for *Teians* are given to motivate participation (Bessant and Francis, 1999). Some *Teians* may have bigger rewards, but the majority are given at a fixed-rate to the individual proposer (Japan Human Relations Association, 1997a; Milakovich, 2006). On the other hand, although the volunteer participation in QCCs is also critical (Crocker *et al.*, 1984), rewards are not directly offered to the meetings but based on the utility of the end results (Ma, 2008; Marin-Garcia *et al.*, 2008; Ma *et al.*, 2010). QCCs aim to make relatively larger changes that are based on specified improvement goals (i.e. themes) (Ishikawa, 1990; Milakovich, 2006). As such, the actual improvement outcomes are compared against the specified goals (Lillrank and Kano, 1989), with rewards given to the accepted themes (Recht and Wilderom, 1998), and based on the improvement achieved (Allen and Kilmann, 2001). Rewards for QCCs are given to the group (Kerrin and Oliver, 2002), rather than to individuals (Crocker *et al.*, 1984).

	QCCs	***Teians***
Results	Improvement outcomes	Participation
Objects	Group	Individuals
Forms	Monetary and non-monetary reward	Fixed-rate money reward

Table 2.3 Differences between the rewards given to QCCs and *Teians*, concluded from Milakovich (2006), Yasuda (1989), Lillrank and Kano (1989) and Ma et al. (2010)

Based on the above comparisons, these two types of improvement practices have different modes of conduct and could result in different outcomes. The improvements made by QCCs could result in dramatic and innovative changes. They are implemented with clear and measurable department/company-wide improvement targets and are normally implemented on a one-off basis. In comparison, the improvements made by *Teians* are always small. They focus on proposers' immediate surrounding area, and are intended to be implemented continuously.

2.4 The Different Perspectives on the Relationship between the Two Improvement Practices

Although the different characteristics of the two improvement practices have been clearly identified, their roles in supporting long-term improvement outcomes remain unclear. In particular, at least four perspectives of the significance of the two practices have been identified in previous studies. They are outlined in the following sections.

2.4.1 Shingo's perspective on continuous improvement

According to Shingo (1987; 1988), the main difference between the two improvement practices is one of orientation. From Shingo's perspective, the Japanese *Kaizen* is not simply a type of improvement with non-stop effort. Arguably, it also places an emphasis on the idea of better processes to gain better results.

As Shingo indicated, the different emphases come from the differences in defining the manufacturing processes. According to the Association for Operations Management, manufacturing may be defined as "a process involved in converting inputs into finished goods" (APICS Dictionary 9th Edition, 1998, p75). Such a process could consist of many sub-processes (e.g., linear, parallel, coupled sub-processes, etc.), and each sub-process can have its own output (Koskela, 1992). Following this, an improvement can be made either on the larger process or on each smaller individual sub-process, as the size of the unit of analysis is the only difference between them (Shingo and Bodek, 1988). As a consequence of this, improvement activities could have been focused more on the sub-processes (Liker and Hoseus, 2008). This is primarily because the outputs of each sub-process' improvement could be seen more easily than that of the overall process improvement (Liker, 2004).

Shingo criticised this type of improvement activity in many of his studies (e.g., Shingo and Bodek, 1988; Shingo, 1990; Shingo, 1992). He began with a different interpretation of the composition of a production system: "production activities may best be understood as networks of processes and operations [not sub-processes]" (Shingo, 1987, p7). A process is "…the flow of products from one worker or machine to another, that is, the stages through which raw materials gradually move to become finished products…" (Figure 2.17); an operation is "…the discrete stage at which a worker may work on different products…" (Shingo and Bodek, 1988, p5). This distinct observation has viewed materials as the objects of the work which determine the process. The workers are the subjects of the work that determine the operations. In this sense, the process may be viewed as the holistic machining procedure related to the flow of materials, whilst the operation could be understood in terms of local working methods used by workers on one machine or several machines. Accordingly, the improvement of operations (local improvement) may generate local results, but may not necessarily lead to holistic process improvement, as a process is not a collection of operations; rather they lie along intersecting axes (Shingo, 1989; Shingo, 1990; Shingo, 1992).

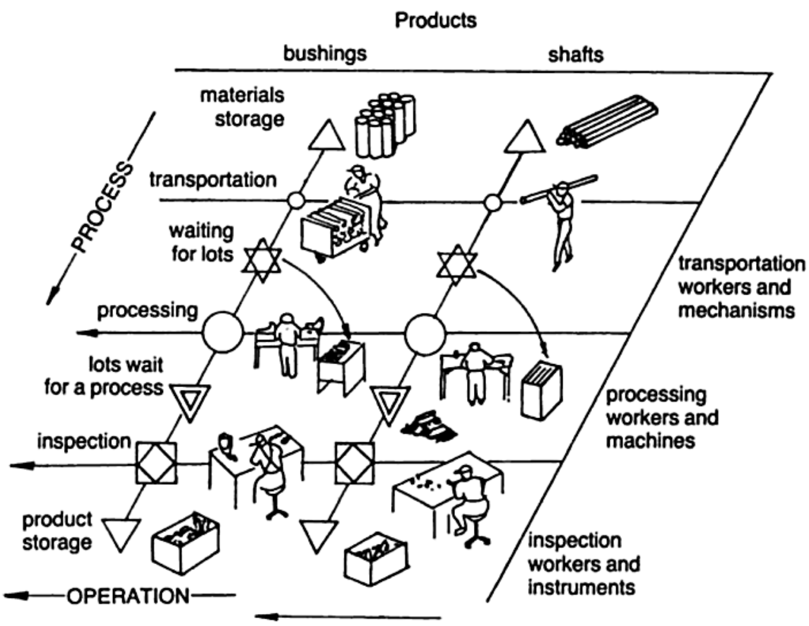


Figure 2.17 The intersecting of holistic process & local operations in a production (Shingo and Bodek, 1988, p4)

This perspective was later popularised by many subsequent studies. For instance, Evans et al. (1990) and Liker and Hoseus (2008) postulated that a process sequences a number of operations to create a production system. Thus, a process refers to a way of doing things or creating a material flow (Koskela, 1992). Buffa and Sarin (1987, p6) also stressed that operations are only “some [local] steps in the overall process”, in which the operations should be treated as a series of local production activities. Womack and Jones (1996) also indicated that a process is a way to transform materials into products (goods or services), whilst operations are some individual jobs or tasks that are performed by workers (on the machines). More recently, Slack et al. (2007, p93) found that “different operations, even those in the same operation, may adopt different types of processes”. In this sense, “the important thing is to think of new work methods, not to make new tools or equipment [to increase local efficiencies]” (Ohno, 1988b, p122).

This is simply because the change of an holistic process would result in the change of local operations, but not necessarily *vice versa* (Isatto and Formoso, 1998, pp., p31; Liker, 2004). For instance, even some significant improvements to some operations may only have a minimal effect on the overall process; only a process driven improvement can result in a thorough change of production (Murman *et al.,* 2002).

Following this perspective, improvements should be implemented with an emphasis on changes in the holistic process. As Shingo argued, "in improving production, process phenomena should be given top priority" (Shingo, 1989, p26). In this sense, QCCs should add more value to improvement results than *Teians*, as QCCs can produce holistic, system-wide process improvement as well as changes to individual operations. In comparison, *Teians* are types of improvement that are only based on participants' personal working area and focus on small changes. They are therefore, less likely to generate holistic process change.

2.4.2 Imai's perspective on continuous improvement

However, Imai's findings showed a different perspective on comparing different improvement practices. Imai considered change to be either incremental or radical (Imai, 1986; Imai, 1997).

	Innovation (*Kaikaku*)	***Kaizen***
Effect	Short-term but dramatic	Long-term and long lasting but undramatic
Pace	Big steps	Small steps
Timeframe	Intermittent and non-incremental	Continuous and incremental
Change	Abrupt and volatile	Gradual and constant
Involvement	Select few 'champions'	Everybody
Approach	Rugged individualism, individual ideas and efforts	Collectivism, group efforts, systems approach
Mode	Scrap and rebuild	Maintenance and improvement
Spark	Technological breakthroughs new inventions and new theories	Conventional know-how and state of the art
Practical requirements	Requires large investment but little effort to maintain it	Requires little investment but great effort to maintain it
Effort orientation	Technology	People
Evaluation criteria	Results for profits	Process and efforts for better results
Advantages	Better suited to fast-growth economy	Works well in slow-growth economy

Table 2.4 Differences between *Kaikaku* and *Kaizen* by Imai (1986, p24)

In contrast to Shingo's view, Imai distinguished between different types of improvement activities based on their implementation time-frames and orientation (Table 2.4). According to Imai, improvement activities can be classified as being continuous or one-off improvements. Continuous improvement is process-oriented and is called *Kaizen* in Japanese. It focuses on the course of the implementation and aims to produce cumulative results from an on-going and incremental change process. The one-off improvement is results-oriented and it is called innovation or *Kaikaku* (改革) in Japanese. It is characterised by its discontinuous and innovative results. Its implementation may require large financial investment to make some dramatic alterations. This perspective has also received a considerable amount of recognition (Choi and Liker, 1995; Terziovski, 2002, pp., p6). Handyside (1997, pp., p16) postulated that '*Kaizen*' and '*Kaikaku*' represent two fundamental approaches to improvement. Bond (1999, p1320) noted that "improvement can be categorised as either incremental small change (*Kaizen*) or innovative step change (*Kaikaku*)". Bateman (2003; 2005) also classified the improvement activities according to different implementing time-frames.

Authors	On-going and process-oriented terms	One-off and results-oriented terms
Deming (1986)	Process quality	Product quality
Ishikawa (1985b)	Quality as process	Quality as results
Imai (1986)	Process-oriented thinking	Results-oriented thinking
Juran (1988)	Quality improvement	Quality planning
Nakajima (1989)	Productive maintenance	Preventive maintenance
Dertouzos et al. (1989)	Incremental product design	Innovative product design
Robinson (2001)	Manufacturing driven management	Profit driven management
Kondou (2003)	Conservative Changes	Dramatic results

Table 2.5 The summary of the two improvement orientations based on Choi and Liker (1995, p594)

Table 2.5 summarises previous research that has compared long-term and process-oriented *Kaizen* to short-term and results-oriented *Kaikaku*. Figure 2.18 compares the impact of these approaches on long-term improvements (Huda, 1992; Nelson *et al.*, 1998; Liker and Hoseus, 2008; Browning and Heath, 2009).

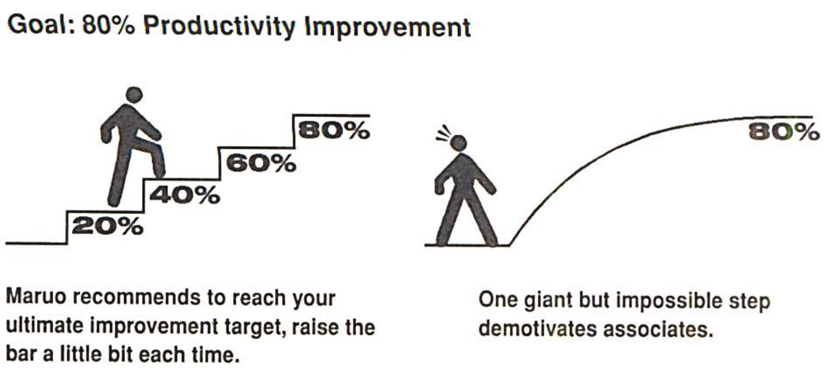


Figure 2.18 The two types of improvement, adopted from Nelson et al. (1998, p42)

Kaizen is a continuous and incremental process (Bateman and David, 2002). The emphasis is on the involving everyone (Bhuiyan and Baghel, 2005, pp., p761) to make suggestions that produce small changes (Harrington, 1995) using common sense (Nihon HR Kyōkai, 1995) and low-cost (Bond, 1999) methods over a prolonged period (Laraia *et al.*, 1999, pp., p2). In this sense, although each small and on-going change in *Kaizen* "may not have a measurable impact, the cumulative effect can be quite profound" (Choi and Liker, 1995, p590), "which in the end produce important and lasting results" (Marin-Garcia *et al.*, 2008, p57).

In comparisons, *Kaikaku* is a discontinuous and breakthrough improvement approach (Bodek, 2004), that makes dramatic alterations (Hines *et al.*, 2004), and creates radical change (Harrington, 1995; Bhuiyan and Baghel, 2005). It requires significant investment in capital (Terziovski and Sohal, 2000; Terziovski, 2002), new technologies or equipment (Nihon HR Kyōkai, 1995, pp., p8) and can take a long time (Sayer and Williams, 2012) to generate "a large and fundamental change of policy, practice, or awareness" (Bodek, 2004, pix). Handyside (1997, p16) indicated that *Kaikaku* is "usually characterised by revolutionary new processes, advanced technologies and high capital investment".

Therefore, the high cost, short-term radical step *Kaikaku*, as opposed to the on-going *Kaizen*, could easily jeopardise the whole improvement process (Soltero and Waldrip, 2002), as doubling the production line needs more investment, but does not necessarily double productivity (Krafcit, 1988). Bateman (2002; 2003) also indicated that a discontinuous improvement activity is easy to adopt (i.e., the universal crash courses), but it would also easily erode back to the pre-improvement level.

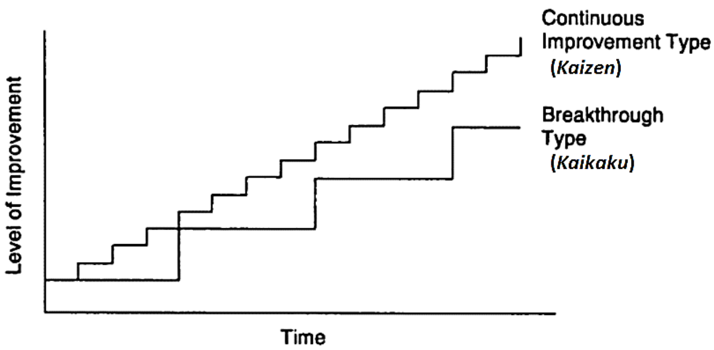


Figure 2.19 Comparison of breakthroughs and continuous improvement, adopted from Suzaki (1993, p133)

In this sense, which is different from Shingo's perspective, improvement should be implemented with an emphasis on the small changes, as they can be implemented continuously, require less cost and always have longer-lasting outcomes (Figure 2.19). As such, *Teians* should be used more than QCCs for implementing continuous improvement. *Teians*, as they have been described above, are small, simple and instant changes that can be made continuously. They are highly dependent on participants' shop floor skills and experience and require little or no monetary support. The QCCs, on the other hand, could be implemented for producing department/company-wide changes. They need more support (e.g., finance, management, and supervisors), must be based on collective ideas, and require approval of managers; thus always take a longer time to finish (e.g., 6-12 months for a QCC theme). They may therefore relatively more difficult to be implemented on a continuous basis.

2.4.3 An extension to Imai's perspective on continuous improvement

Some studies have investigated the mutual relationship between *Kaizen* and *Kaikaku* based on their outcomes. According to Imai's findings, the two types of improvement could generate different improvement outcomes, and evidently, the outcomes from *Kaizen* can cause the outcomes from *Kaikaku*, but not *vice versa*. For instance, Lillrank and Kano (1989) indicated that process-oriented improvement is assumed to cause results-oriented output, whilst process-oriented outcomes cannot be achieved without a corresponding process improvement. This was in line with two other subsequent studies, "… getting the process under control, results are automatically improved" (Huda, 1992, p10) as "processes must be improved for results to improve" (Liker and Hoseus, 2008, pxxix).

Furthermore, this perspective was further extended to the quality improvements in many studies, as quality improvements require process changes (Utterback and Abernathy, 1975). For instance, Deming (1986) drew a sharp distinction between process-orientation manufacturing and goal-orientation manufacturing. He argued that quality can either be a company process or goal, but quality as a company goal could only "lead to the achievement at the price of inspection and dismal productivity", only "the improvements in the processes could lead to quality as a natural consequence" (Choi and Liker, 1995, p592). A very similar finding can be found in one of Juran's (1988) studies. He compared the differences between process-driven and goal-driven improvements and concluded that process-driven improvements could produce a real quality change, whilst goal-driven improvement could only generate redefined strategic plans. Schonberger (1982a) also investigated the different impact of the two orientations on the relationship between quality and productivity improvement. He found that only quality as a process could produce productivity changes, whilst productivity as a result would not necessarily generate quality changes. Another major study by Ishikawa's (1985b) demonstrated the impact of the different orientations by linking them to produce quality improvement. He postulated that developing a quality process should be a prerequisite to quality results, as only the quality improvement in the process could lead *en route* to the creation of a quality product.

Following the literature, quality improvement should be built into the course of the improvement activities, but not treated as the end-result. Both QCCs and *Teians* can produce quality improvements. QCCs were originally established to produce quality processes, but when they are implemented with pre-set improvement targets, the improvement might focus more on the results than the process. *Teians*, in comparison, focus on the course of changes and therefore, should have a greater impact on quality improvement.

2.4.4 The perspective of mutually inclusiveness of the two improvement practices

Despite the dramatic differences, some previous studies have suggested that *Kaizen* and *Kaikaku* may need to be employed in conjunction with each another to achieve the full benefits of improvement (Kono, 1982; Huda, 1992; Elger and Smith, 1994; Bicheno, 2001; Bodek, 2004; Bessant *et al.*, 2005; Jones, 2005; Gåsvaer and von Axelson, 2012). For instance, Handyside (1997, p18) argued that "innovation [*Kaikaku*] and *Kaizen* are not competing alternatives. Neither one nor the other is sufficient to give an organisation a competitive edge in world markets…*Kaizen* is the superstructure which, when added to the capabilities of shared technologies [*Kaikaku*], makes the crucial difference". This is because *Kaikaku* and *Kaizen* are actually "complementary" to each other rather than being "mutually exclusive" (Bond, 1999, p1320). This is in line with a study by Bessant et al. (1994, p18), who found that "continuous improvement [*Kaizen*] is a powerful tool and one which unlocks a neglected source of organisational innovation [*Kaikaku*]". More recently, a combination of these two methods, namely *Kakushin* (Japanese for perpetual improvement, 革新), has been implemented by Toyota (Kondou, 2003; Stewart and Raman, 2007; Yamamoto, 2010; Shamshurin, 2011).

On the one hand, *Kaikaku* is good at solving one-off problems (Bhuiyan and Baghel, 2005). It provides an opportunity for dramatically improving productivity and product quality by using new technology (Imai, 1986; Bessant *et al.*, 1994; Radharamanan *et al.*, 1996; Handyside, 1997; Imai, 1997; Terziovski and Sohal, 2000). However, it also has some drawbacks in that implementing innovation may become costly (require monetary, management, and line supervisors' support) and risky (the results would easily erode back to the pre-improvement level) in the long-run (Figure 2.20).

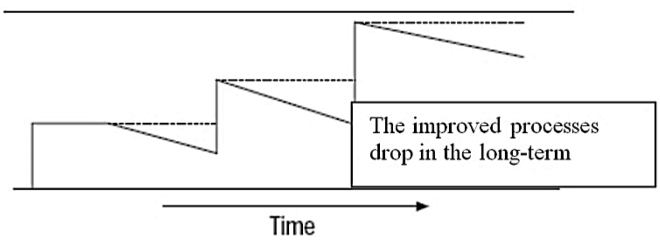


Figure 2.20 The improvement via *Kaikaku* only, adopted from Imai (1986, p26)

On the other hand, *Kaizen* is a long-term and incremental improvement process. It requires little or no investment. It causes less resistance (Imai, 1986; Imai, 1997, pp., p89). However, it requires more personal skills and experience for its implementation. It may also take a longer time to make large and holistic changes (Shingo, 1987; Shingo and Bodek, 1988).

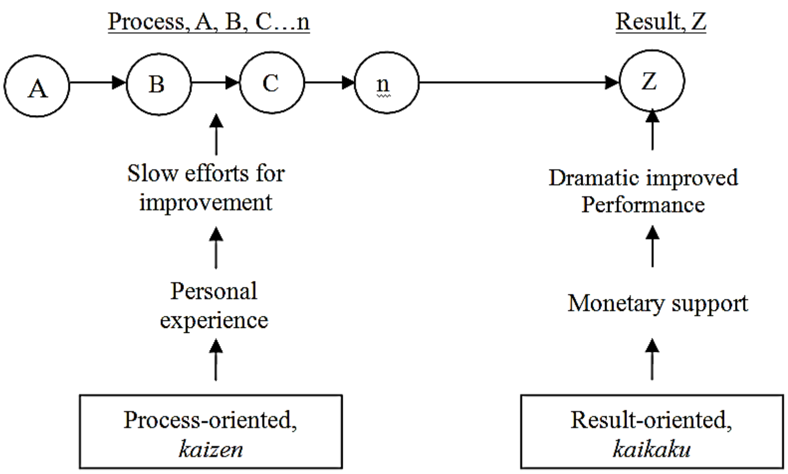


Figure 2.21 The mutually inclusion of *Kaizen* and *Kaikaku* in order to improve end-result based on Imai (1986, p18)

Therefore, as suggested, in order to get more comprehensive improvement outcomes, QCCs and *Teians* should be implemented together as a company-wide *Kakushin* (Bessant *et al.*, 1994; Savolainen, 1999; Murata, 2007) (Figure 2.21).

2.5 Summary

A new production system was developed by Toyota in Japan. It was originally named the TPS, but now the term 'Lean Production' is widely accepted and used to describe its 'Lean nature'. Lean Production is renowned for reducing costs whilst maintaining quality. It was a successor to Mass Production.

The Japanese philosophy of perfection in manufacturing industry aims to improve the production system continuously. However, there is confusion between processes and operations in terms of improving the production system. Many studies have shown that process and operation represent two types of activities in a production system; the process is a sequence of operations. The shift from conventional production to the TPS or Lean Production has proved to be a process improvement.

Sustaining *Kaizen* continuously is one of the core features in the Japanese manufacturing industry. However, the implementation of *Kaizen* has proved to be difficult. In particular, different perspectives on implementing *Kaizen* were identified from previous research.

The next chapter introduces the Lean shop floor management tools. It critically evaluates and analyses their functionality, implementation method and explains their roles in supporting the implementation of *Kaizen*.

Chapter 3 The Building Blocks of Shop Floor Management

This chapter critically evaluates the four building block tools of shop floor management: 5S practice, waste removal, standard operations and visual management. The chapter is divided into 5 sections: section 3.1 provides an introduction and analyses the differences between the basic shop floor practices in maintenance and improvement. Section 3.2 - 3.5 show the characteristics and examine the implementation of these building block tools. Further, this chapter also reviews how they act as the building blocks for implementing continuous improvement on the shop floor.

3.1 Review of Shop Floor Problem Solving for Implementing Continuous Improvement

The shop floor is considered one of the most important areas in manufacturing industry (Liker, 2004; Womack and Jones, 2005), as the majority of manufacturing activities happen there (Handyside, 1997). The shop floor is also the first port of call if a problem (e.g., abnormality) arises. As such, it needs to be improved continuously (Imai, 1986; Imai, 1997). This finding has been widely supported by a number of subsequent studies (e.g., Harrington, 1995; Bond, 1999; Terziovski and Sohal, 2000; Soltero and Waldrip, 2002; Terziovski, 2002). In particular, as Kobayashi (1990, p163) indicated, in manufacturing industry, a successful continuous improvement process "must originate from the workplace [shop floor] and be executed in the workplace [shop floor]". There, the implementation of *Kaizen* requires the support from shop floor management (Figure 3.1 vs. Figure 2.12).

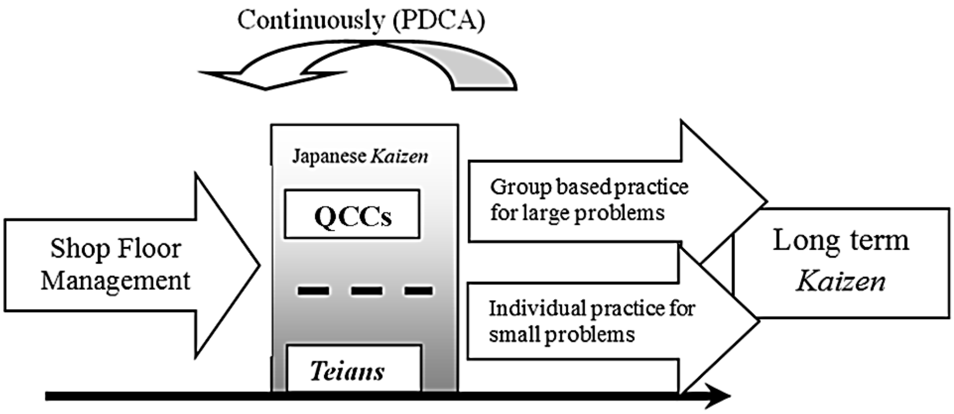


Figure 3.1 The Japaese *Kaizen* with the support of shop floor management

The Lean Production shop floor is managed effectively by *Genba Kanri*, which is Japanese for shop floor management. In particular, *Genba* (or *Gemba*) is a Japanese term that means 'real place' (現場), but has now been adopted into management terminology to mean 'workplace' or 'shop floor'. *Kanri* is Japanese for 'basic management' or 'control' (管理) (Imai, 1997). *Genba Kanri* (現場管理), therefore, is Japanese for basic workplace or shop floor management (Granger, 1993; Hicks, 2007; Hill, 2012). *Genba Kanri*, or shop floor management, is a robust approach forming the foundation for the two important shop floor functions: maintenance and improvement (Handyside, 1997; Imai, 1997) (Figure 3.2).

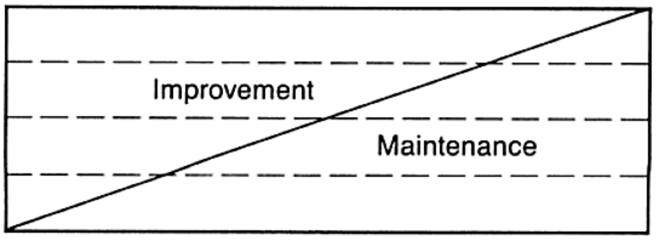


Figure 3.2 Two important job functions perceived by managers on the shop floor (Imai, 1997, p5)

3.1.1 The importance of shop floor maintenance

According to some studies (e.g., Bessant *et al.*, 1994; Graham, 1995; Jha *et al.*, 1996; Recht and Wilderom, 1998; Aoki, 2008; Liker and Hoseus, 2008), implementing continuous improvement is complex, as it depends on various characteristics of the organisation (e.g., company culture, strategy framework, operations, human resource policies, practices, etc.). However, the idea of improving things continuously is not difficult in itself. It is the endless quest to identify problems and provide solutions (Imai, 1997; Bond, 1999; Dennis and Shook, 2007).

In order to implement improvement effectively and continuously (Liker, 2004), it is important to (Figure 3.3): first define the problems clearly (Adams *et al.*, 1999; Krar, 2003), based on an accurate grasp of the facts (Ishikawa, 1990); search for the causes of any variation (Bhuiyan and Baghel, 2005; Hines *et al.*, 2008); and implement corrections at source (Choi, 1995).

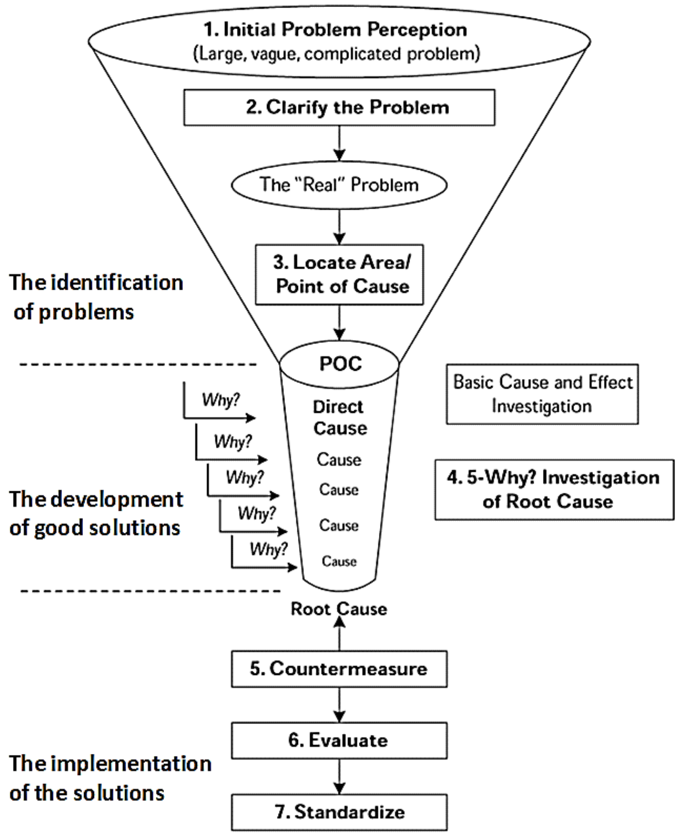


Figure 3.3 The practical shop floor problem-solving process, adopted from Liker (2004, p256)

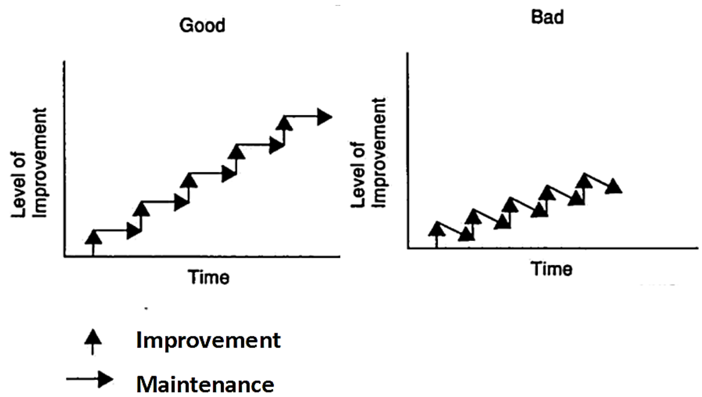


Figure 3.4 The importamce of good shop floor maintenance (Suzaki, 1993, p97)

Shop floor maintenance has been used as the cornerstone (Imai, 1997; Rita, 2001) to provide support for implementing continuous improvement (Shah and Ward, 2003) (Figure 3.4). Shop floor maintenance has been defined as "activities directed toward maintaining current technological, managerial, and operating standards" (Imai, 1986, p5). It essentially includes all actions undertaken as part of production activities, such as manufacturing, administration and management (Handyside, 1997). More importantly, shop floor maintenance is also used to introduce shop floor orders (Herron, 2006), preserve and regulate current production processes (Hirano, 1988, pp., 208) and identify problems at source (Kobayashi, 1990) (i.e., Total Productive Maintenance or TPM to improve equipment maintenance practices and prevent and predict equipment failures). A well-maintained shop floor allows the effective prediction of problems (Herron, 2006) and ultimately leads to successful shop floor improvement (Imai, 1997, pp., p3).

Therefore, implementing shop floor maintenance activities is closely related to continuous shop floor improvement (Figure 3.5). These two important shop floor functions (Imai, 1997) are noted as being "parallel activities" with regard to shop floor management (*Genba Kanri*) (Handyside, 1997, p15). Imai (1986, pxx) once argued that "improvement is a mind-set inextricably linked to maintaining and improving standards".

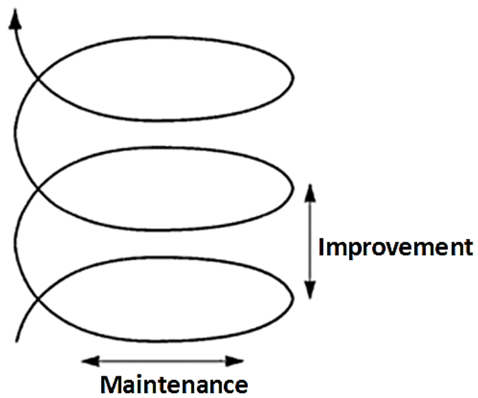


Figure 3.5 Maintenance and improvement cycles (Handyside, 1997, p15)

3.1.2 The building block maintenance tools for improvement

The Japanese *Genba Kanri* contains many tools for maintenance and improvement (Feld, 2001). These tools are identified in many of the recent shop floor management specific studies, such as Imai (1997, pp., p20), Handyside (1997), IEE (1997) and Liker's (2004). Appendix A lists some of the tools identified in these studies. They are important both for shop floor maintenance and improvement.

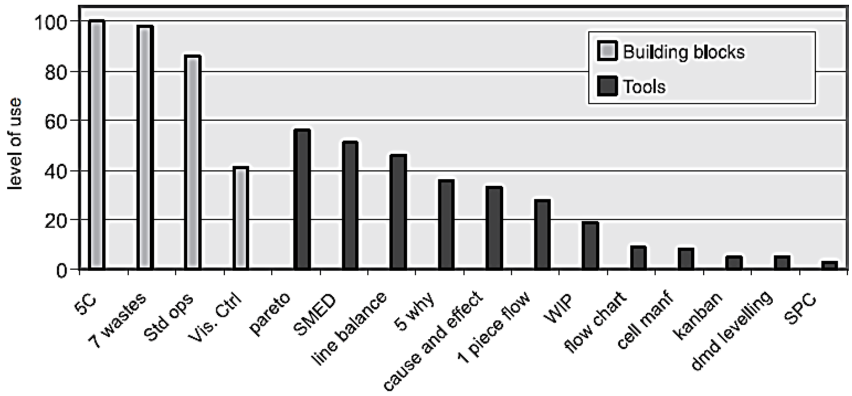


Figure 3.6 Frequency of use of shop floor management tools, adopted from Bateman and Brander (2000, p242)

Among these tools, four are mentioned many times. They are 5S (a set of shop floor management practices, that will be detailed in Section 3.2), waste removal (Section 3.3), standard operations (Section 3.4), and visual management (Section 3.5). Imai (1986) found these tools were essential elements for shop floor maintenance, but they are also specially used for *Genba Kaizen* (shop floor continuous improvement). These four tools (Figure 3.6) were studied by Bateman (2000; 2002; 2005) and featured in the widely promoted Common Approach Tool Box (Figure 3.7) of the Industry Forum (2008) for improvement measured by quality, cost, development and partnership (QCDP).

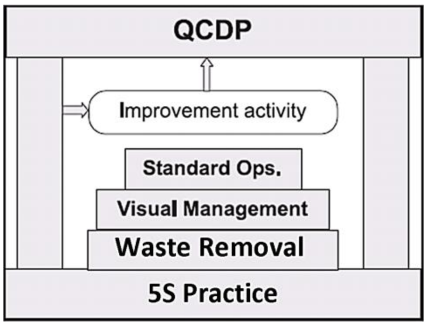


Figure 3.7 The Common Approach Tool Box, adopted from Bateman and Brander (2000, p242)

3.2 5S Practice

5S practice (五常法) is one of the Japanese manufacturing approaches used in *Genba Kanri* (shop floor management) (Handyside, 1997). It consists of five simple tools for maximising shop floor performance (Hirano, 1996; Imai, 1997). '5S' refers to the names of the tools as they appear in Japanese (Table 3.1): *seiri* (structurise/organisation), s*eiton* (systematise/orderliness), *seiso* (sanitise/cleanliness), *seiketsu* (standardised cleanup) and *shitsuke* (self-discipline) (Osada, 1991; Hirano, 1993).

Japanese	Japaense Kanji	English	Meaning	Typical example
Seiri	整理	Structurise	Organisation	Throw away rubbish
Seiton	整頓	Systematise	Neatness	30-second retrieval of document
Seiso	清掃	Sanitise	Cleaning	Individual cleaning responsibility
Seiketsu	清潔	Standardise	Standardisation	Transparency of storage
Shitsuke	素養	Self-discipline	Discipline	Do 5S daily

Table 3.1 The English equivalents, meanings and typical examples of 5S practice, concluded by Ho (1998, p55)

5S is a relatively low-cost (Osada, 1991), simple (Dossenbach, 2006b) and common-sense approach (Hirano, 1993; Hirano, 1996) to support shop floor maintenance (Handyside, 1997). It was originally used for identifying and eliminating shop floor waste (Ohno, 1988a; Main *et al.*, 2008, pp., p41) and ensuring the safety of the workforce (Osada, 1991; Terziovski and Sohal, 2000; Dossenbach, 2006a). The 5S practice is a well-organised, highly integrated and powerful approach to increasing product quality (Ho *et al.*, 1995; Ho and Cicmil, 1996), and sustaining shop floor continuous improvement (*Genba Kaizen*) (Hirano, 1990; Osada, 1991; Gapp *et al.*, 2008).

3.2.1 The origins of 5S practice

5S practice has its origins in the Japanese culture (Kobayashi *et al.*, 2008). Many Japanese companies are renowned for their cleanliness and the ordered arrangement of their shop floor (Lim *et al.*, 1999). It is a simple but effective tool that has been applied by Toyota since the 1940s (Hobbs, 2004). Until the late 1980s, it was systemically introduced by Takashi Osada (1991) and extensively promoted by Hiroyuki Hirano (1990; 1993; 1996). In the 1990s, about 80 *per cent* of Japanese companies were practising 5S (Ho *et al.*, 1995).

However, despite the fact that 5S has received more recognition in Japan than in any other country, and is embedded into the Japanese culture (Osada, 1991), some studies have suggested alternative origins. For instance, critics have argued that the 5S practice was developed neither by Osada and Hirano, nor from a culture that is solely Japanese. According to Gapp et al. (2008) and Kobayashi et al. (2008), the two Japanese authors and outstanding practitioners of 5S were responsible only for its promotion. In addition, a number of studies have suggested that the 5S practice is not a Japanese cultural feature and does not belong solely to Japanese manufacturing industry. In particular, Handyside (1997, p4) indicated that “*Genba Kanri* [which includes 5S practice] is not a Japanese phenomenon…it [rather] is derived from the best traditions of Western management”.

Norwood (1931) claimed that the Ford River Rouge plant implemented a similar shop floor management tool. Levinson (2002, pp., p11) also found that elements of 5S had appeared in the Ford workplace by 1911. A study by Bicheno (2008, pp., p56) generated similar findings in this field. In the UK, the 5S practice was adopted by the army and many manufacturing companies. Levinson and Tumbelty (1997, p31) indicated that "the British Army often owed its successes to discipline and organisation [which are the two of the important processes in 5S practice]". Ho et al. (1995, p21) highlighted that "the majority of the UK companies have actually built the concept [of 5S] into their day-to-day activities…".

Nevertheless, in spite of its long-term usage both in Japan and the West (Levinson and Tumbelty, 1997), the 5S practice has been adopted and implemented differently (Ho *et al.*, 1995; Gapp *et al.*, 2008) (e.g., Appendix B). The Japanese 5S has had more profound outcomes than the Western 5S. In Japan, 5S practice is essential for shop floor improvement (Bateman and Brander, 2000; Bateman and David, 2002). Hyland (2000) found that the 5S practice was rated one of the least applied and important shop floor management tools in some European countries (Sweden, Denmark, The Netherlands, Finland, and the UK) and Australia.

3.2.2 Implementation of 5S practice for continuous improvement

The 5S practice is a basic, well-organised (Ho, 1997; Ho, 1998) and inexpensive tool (Dossenbach, 2006b). However, the implementation of 5S is varied (Gapp *et al.*, 2008) and has different aims and purposes (Kobayashi, 1990). For instance, in 1998, Ho performed a cross-sectional case study to examine the implementation of the 5S practice in ten case companies. He identified that 5S practice could be used for multiple purposes, such as improving product quality and productivity, creating a pleasant working environment and promoting a framework for continuous improvement. A recent publication by Hobbs (2004, pp., p131) reported that the *shitsuke* (self-discipline) process, the last stage of 5S practice, should be implemented by managers to reinforce and demonstrate their leadership. Moreover, Becker (2001) and O'hEocha (2000) have enriched these findings and indicated that 5S practice could also be used for shop floor safety; for example, Boeing uses it mainly for 'workplace safety' (Ansari and

Modarress, 1997). In fact, there are at least three general perspectives of 5S practice that have been implemented by practitioners.

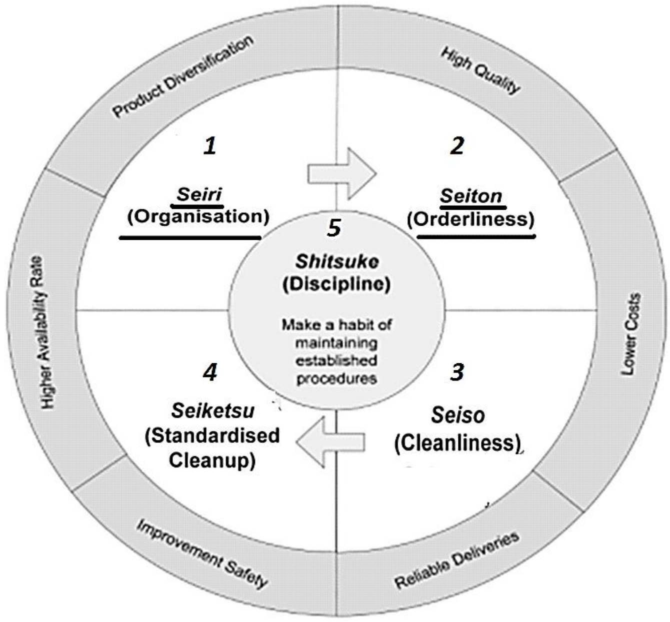


Figure 3.8 The five simple tools of 5S practice by Hirano (1993, p13)

Initially, according to Hirano (1990; 1993; 1996), the implementation of 5S is a straightforward method for creating a neat and tidy workplace. Hirano (1996, p26) indicated, the "two most crucial elements [of 5S] are [the processes of] organisation [*seiri*] and orderliness [*seiton*]" (Figure 3.8). *In addition*, He (1993) suggested that the aim of the 5S practice is to identify and remove unnecessary shop floor items. Following this, the 5S practice is mainly a series of tools for 'housekeeping' or shop floor maintenance. This understanding is accepted by some studies (Miom and Caropenter, 2000; Becker, 2001; Eckhardt, 2001; DiBarra, 2002). In particular, the English translation of 5S practice into 'housekeeping' is commonly agreed in the West. For instance, Slack et al. (2007, p470) defined 5S "as a simple housekeeping methodology to organise work areas…" .

However, according to some other studies (Herron, 2007; Herron and Braiden, 2007; Gapp *et al.*, 2008; Kobayashi *et al.*, 2008), Hirano's conclusion may have overlooked or omitted some of the important philosophical ideas of 5S practice. Osada (1991) identified that, although dealing with waste is always important on the shop floor, the implementation of 5S is not just about doing housekeeping to eliminate wastes or tidy up the workplace. Osada's study placed the emphasis more on shop floor discipline.

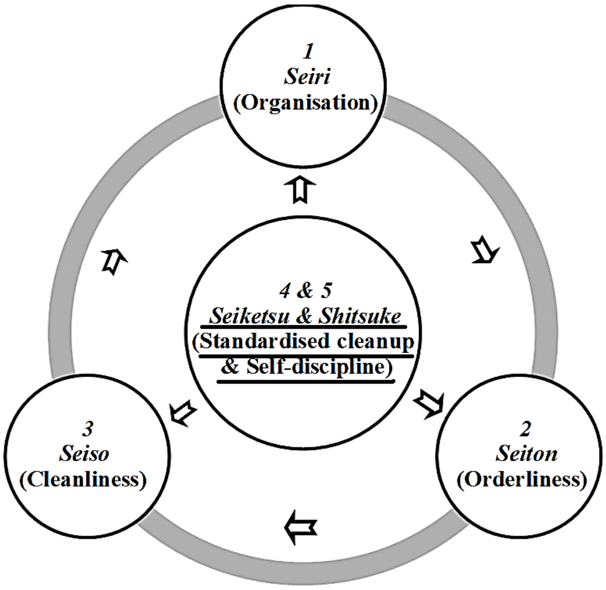


Figure 3.9 5S practice adopted from Osada (1991)

As such, rather than the first two processes, Osada (1991) suggested that the most important parts of the 5S practice are the last two processes (Figure 3.9): standardisation (*seiketsu*) and self-discipline (*shitsuke*). Following this, the 5S practice is more than a series of tools for 'housekeeping' or shop floor maintenance; it is also a programme for regulating shop floor standards (e.g., implementing standard operations). Moreover, Osada's study highlighted the importance of discipline for participation. He advocated that "5S's cannot succeed without discipline" (Osada, 1991, p158). Thus, the 5S practice is also a company-wide programme that requires total participation "so that everybody can get it right" (Osada, 1991, p143). This type of 5S is also accepted by some subsequent studies as an effective approach to develop workers' self-discipline for maintaining shop floor standards to prevent waste (Ho *et al.*, 1995; Gapp *et al.*, 2008; Kobayashi *et al.*, 2008).

More recently, Liker (2004) produced a comprehensive model of 5S implementation. He argued that the 5S practice should be used as a business excellence strategy for organisational development. Following this, all of the 5S tools are equally important and they should be implemented interdependently to provide a platform for business success (Figure 3.10).

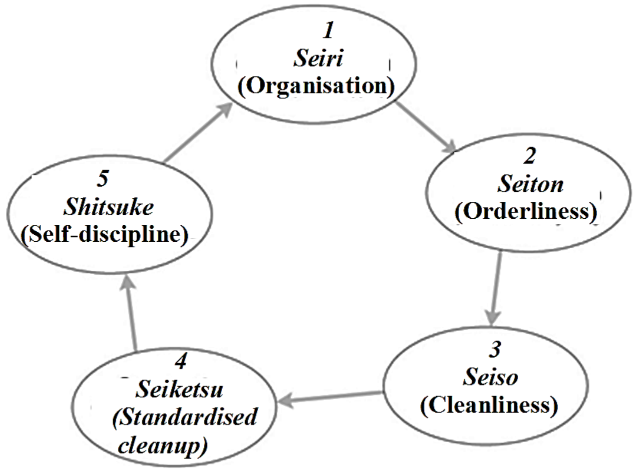


Figure 3.10 5S practice adopted by Liker (2004, p151)

This proposition was also found in many other similar studies (e.g., Ho and Cicmil, 1996; Ho, 1997; Ho, 1998; Bateman and Brander, 2000; Hobbs, 2004, pp., p36; Bateman, 2005; Herron, 2007; Herron and Hicks, 2008). Kobayashi et al. (2008) and Gapp et al. (2008) argued that the 5S practice must be used as a holistic approach and that all of its techniques should be performed simultaneously to enhance the results of other shop floor activities. Therefore, the 5S practice is not only a practical tool for maintenance or housekeeping (Hirano, 1993; Hirano, 1996), or an approach to promote self-discipline (Ho *et al.*, 1995). It is also a control mechanism that ensures and supports the working of many other Lean tools, such as continuous improvement (Choudri, 2002; Simons and Zokaei, 2005; Herron, 2007).

According to Kobayashi et al. (2008), this type of 5S practice is widely used in the Japanese manufacturing industry to pursue long-term shop floor improvement. Indeed, in many Japanese companies, the 5S practice has been used as a holistic management approach that also integrates with other maintenance and improvement activities including: TPM (Total Productive Maintenance, to predict and prevent equipment failures); TQM (Total Quality Management, to produce quality right in the first place) (Imai, 1986; Imai, 1997); other tools, such as waste removal and standard operations (Bateman and Brander, 2000).

3.3 Waste Removal

The relentless effort to reduce waste is one of Lean Production’s major aims (Japan Management Association, 1985; Hines and Taylor, 2000) and one of the key processes throughout the implementation of 5S practice (Hirano, 1990; Osada, 1991). Ohno (1988a, p95) once claimed, the "complete elimination of waste is the basis of the Toyota Production System". Hino (2006, p73) also found that "Toyota management is centred on the elimination of *muda* [waste]". In fact, waste removal is one of the building blocks that supports shop floor improvement (Shingo, 1987, pp., p35; Bateman and Brander, 2000).

The term 'waste', known as '*muda*' (無駄) in Japanese, is defined as activities that do not add value to the final good or service (APICS Dictionary 9th Edition, 1998), "the needless, repetitious, movement that must be eliminated immediately" (Ohno, 1988a, p57), or "any activity that consumes resources without creating value for the customer" (Toshiko and Shook, 2007, p8). Waste is also the result of poor quality and the application of incorrect management methods (Bicheno, 1991).

In one of Henry Ford's early publications, he used the idea of non-value adding to describe physical waste, such as the waste of materials and the wasted effort generated by human labour (Ford, 1926; Levinson, 2002). Later, Shingo (1987, pp., p19) developed his own theory of value adding and distinguished two types of work on the shop floor: work that increases value; and work that only increases cost. Following this, 'waste' not only refers to physical waste (e.g., waste of materials), but also includes non-value adding work (e.g., overproduction).

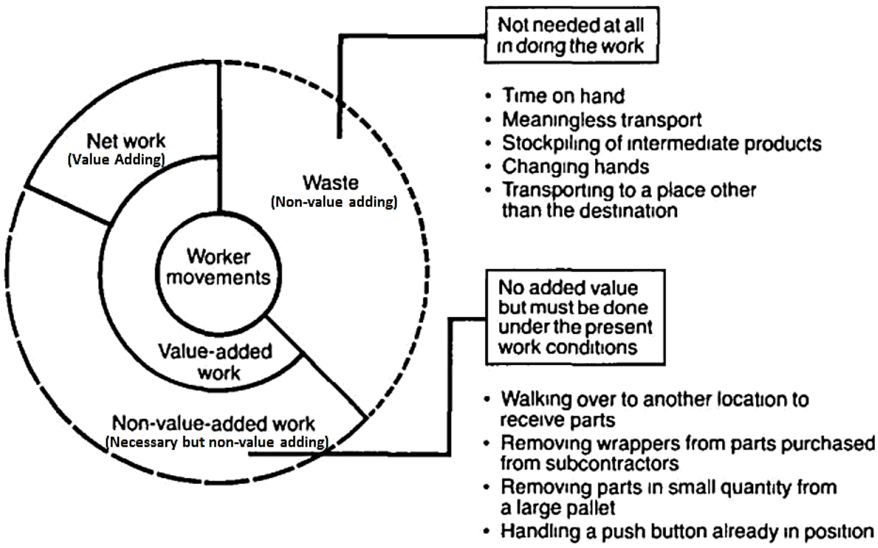


Figure 3.11 Work versus waste by Ohno (1988a, p58)

In 1988, Ohno further improved Shingo's theory. He indicated that all shop floor activities can be divided into three categories (Figure 3.11) value adding (actual work), non-value adding (waste), and necessary but non-value adding (auxiliary work). As such, shop floor waste removal includes both the elimination of the non-value adding activities and the minimisation of the necessary but non-value adding activities (Imai, 1997).

3.3.1 Identification of the different shop floor muda

To achieve a constant 'Lean' standard, waste must always be correctly identified and ruthlessly removed from the shop floor (Ohno, 1979; Hines and Rich, 1997). "The foundation of the Toyota Way is based upon this simple yet elusive goal of identifying and eliminating waste in all work activities" (Liker and Meier, 2006, p34). Shingo (1988) once claimed that most shop floor employees would like to eliminate waste only if they could identify it. However, the correct identification of waste is not always easy (Shingo, 1987, pp., p19). Incorrect identification can lead to the failure of the overall waste elimination process (Japan Management Association, 1985). In particular, waste exists in many forms and can get hidden anywhere (e.g., in policies, procedures, process and product designs and in operations) (Bicheno, 1991; Seth and Gupta, 2005).

For instance, overproduction is the root of many other types of waste (Womack *et al.*, 1990; Womack and Jones, 1996; Hines and Taylor, 2000; Bodek, 2004). Ohno said: "the more inventory [overproduction] a company has… the less likely they will have what they need" (cited in Liker, 2004, p104). It not only generates waste of materials and human labour, but also relates to many other production problems (e.g., low product quality and inflexibility). As such, overproduction is the most serious type of waste on the Lean Production shop floor that needs to be reduced/eliminated (Sugimori *et al.*, 1977; Ohno, 1988a; Shingo, 1989; Shingo, 1990). Ohno (1988a, p59) indicated that "the waste of overproduction - is our [Toyota's] worst enemy - because it helps to hide other wastes". Hence, Lean Production aims to achieve the complete elimination of all overproduction (Ohno, 1988a) by producing products just-in-time (Bicheno, 2004; Slack *et al.*, 2007).

However, overproduction is understood differently in Mass Production. Overproduced WIP (work in progress) and final products are treated differently. Although Ford (1926, p112) suggested that "having a stock of raw material or finished goods in excess of requirement is waste", overproduction always exists on the 'just-in-case' ('just-in-case' verses 'just-in-time', what it needs, when it needs, with exact amount) shop floor and is considered to be a safety buffer along the production line (Bicheno, 2004; Bodek, 2004). As a result, many other types of waste behind overproduction are covered up. Overall, waste in Mass Production has increased (Womack *et al.*, 1990; Womack and Jones, 1996).

***Muda* types**	**Definition**
Overproduction	Producing items earlier on in greater quantities than needed by the customer
Inventory	Excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay
Repair/rejects	Production of defective parts or correction
Motion/movement	Any movements employees have to perform during the course of their work other than those adding value to the part
Processing/overprocessing	Taking unneeded steps to process those parts
Waiting	Workers merely serving as watch persons for an automated machine, or having to stand around waiting for the next processing step
Transport/conveyance	Moving work in process (WIP) from place to place in a process, even if it is only a short distance

Table 3.2 The seven types of waste identified by Ohno and Shingo (Ohno, 1988a, p9; Imai, 1997, p75)

As such, "learning to see waste [correctly] is an important first step" (Dennis and Shook, 2007, p24). Over the years, many common types of shop floor waste have been identified. In particular, Ohno and Shingo identified seven different types of non-value adding activity on the shop floor (Ohno, 1988a; Hines and Rich, 1997) (Table 3.2). Since then, with the continuous development of shop floor management, a number of other types of waste have been identified (Table 3.3).

***Muda* types**	**Definition**	**Authors**
Making the right product inefficiently or wrong product efficiently	Inspection inefficiency; Wasting time, efforts and materials on making a wrong product	Bodek (2004, pp., p41), Bicheno (2004) and Womack and Jones (1996)
Untapped human potential (suggestion/creativity)	Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to the workforce	Polcyn and Engelman (2006), Bicheno (2004), Bodek (2004, pp., p41) and Liker and Meier (2006)
Inappropriate production systems	The use of a wrong system by improving the operations not the processes, such as the improvement of MRP or ERP	Bicheno (2004)
Energy	Waste of all finite resources of most energy sources	Bicheno (2004)
Materials	Waste of raw materials or parts from suppliers	Bicheno (2004) and Womack et al. (1990)
Time	Poor utilisation of time results in stagnation	Imai (1997)
Cost	Including too much overhead	Bodek (2004, pp., p41)
Behaviour	Working behaviour that do not add any values	Emiliani and Stec (2004)
Knowledge disconnection	Horizontal, vertical or temporal knowledge disconnection within a company, or between the company and its customers and suppliers	Dessnis (2007, pp., p24)

Table 3.3 The different types of waste and their associated authors

Moreover, Ohno (1988a) indicated that two other types of shop floor activities are closely related to shop floor waste. They are *mura* (inconsistency, 斑) and *muri* (unreasonableness or overburden, 無理). Together with *muda* (waste, 無駄), they are the shop floor three Ms (Figure 3.12). These three Ms are the consequences of "insufficient standardisation and rationalisation" (Ohno, 1988a, p41) and the unbalanced flow of production (Liker, 2004). Hence, the three Ms also need to be removed continuously from the shop floor, such as through the implementation of stabilised and even production processes (e.g., '*heijunka*' 平準化, is the Toyota's concept of level scheduling by mixing product models) (Monden, 1994; Imai, 1997; Vaghefi *et al.*, 2000; Dennis and Shook, 2007). Liker (2004, p115) claimed that "achieving *heijunka* is fundamental to eliminating *mura*, which is [also] fundamental to eliminating *muri* and *muda*".

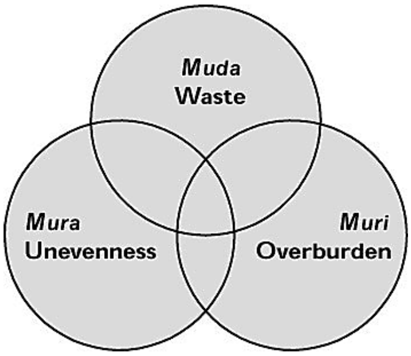


Figure 3.12 The three Ms of Toyota Production System, adopted from Liker (2004, p115)

3.3.2 Implementation of the waste removal for continuous improvement

Once waste has been correctly identified, it needs to be removed. In manufacturing industry, a wide range of waste removal methods have been identified (Bicheno, 1991). In an analytical study by Hallihan et al. (1997), the authors systematically developed a comprehensive series of waste elimination/prevention methods based on many previous studies (e.g., Table 3.4).

	Methods	Purposes
1	Multiskilling or flexible or cross-trained workforce and job enlargement or enrichment	elimination
2	WIP reduction and small lot sizing	elimination
3	JIT purchasing	elimination
4	Total productive maintenance/ preventive maintenance	elimination
5	Setup reduction	elimination
6	Product simplification/component standardization/product modularization	elimination
7	Quality at source or operator / centred quality control	elimination
8	Levelled and mixed production	elimination
9	Layout improvement manufacturing/group technology/dedicated lines/ `U' shaped lines	elimination
10	*Visual control including standard operations and Andon systems*	elimination and prevention
11	5S practice	prevention
12	Pull control/*kanban* (看板)	prevention
13	Autonomation/autonomous defect control	prevention

Table 3.4 The 13 waste elimination/prevention methods concluded by Hallihan et al. (1997, p908)

Effective waste elimination requires the discovery of the sources (Ohno, 1979; Hines and Rich, 1997). Suzaki (1987) and Seth and Gupta (2005, pp., p45) suggested that creating a value stream is one of the most effective ways to identify waste from its sources. A value stream is "a far more focused and contingent view of the value-adding process" (Hines and Rich, 2001, p46). It is defined as the set of specific activities that are necessary along the production line to create a product from the raw material to the final output (Womack and Jones, 1996, pp., p19; Rother and Shook, 2003, pp., p3; Allen, 2010, pp., p122).

1	Cycle time (how often does a piece come out of the process)
2	Changeover time (time from the last good piece of product A until the next good piece of product B)
3	Uptime (how often the machine is in good working order when we need it)
4	Number of operators

Table 3.5 The typical data needed for performing VSM on the shop floor (Duggan, 2002, p7)

The value stream mapping (VSM) tool (Table 3.5) was developed within manufacturing industry to aid the shop floor mapping process (Allen, 2010). The VSM is an effective tool for analysing and quantifying the shop floor waste and its sources (Womack and Jones, 1996; Liker, 2004). It maps the shop floor flows and materials (Jones and Womack, 2002) and identifies each process step necessary to keep track of all activities (Seth and Gupta, 2005). Once the value stream (Figure 3.13) has been mapped, most of the non-value-added activities can be discovered and eliminated; value-added work can be created (Murman *et al.*, 2002, pp., p6; Rother and Shook, 2003); improvement opportunities can also be identified (Seth and Gupta, 2005; Dennis and Shook, 2007); and eventually the future ideal state of shop floor process and activities could be created (Chen *et al.*, 2010).

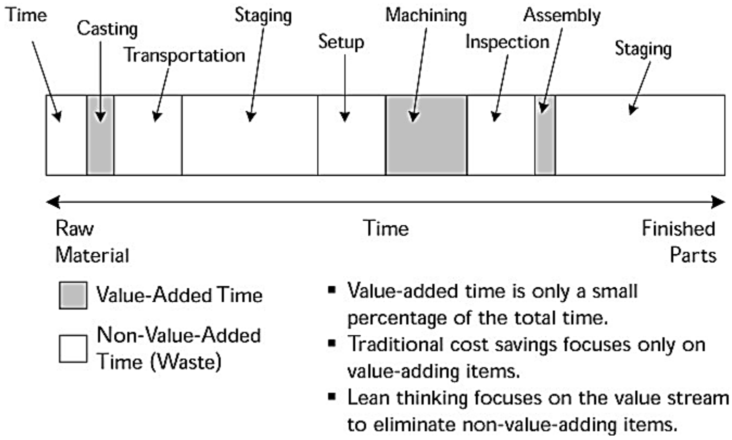


Figure 3.13 Example by Liker (2004, p30), identify the waste to create a value stream

The value stream mapping (VSM) tool was pioneered in some Japanese manufacturing companies (e.g., Toyota) (Hines and Rich, 1997), but has since been widely promoted by many studies (Hines and Rich, 1997; Rother and Shook, 2003; Abdulmalek and Rajgopal, 2007). Hence, it is now also broadly used by many other companies outside of Japan as an essential tool for positioning and eliminating waste, and supporting improvement (Román, 2009).

Furthermore, if the sources of waste can be clearly identified, understood and removed, they could be prevented from recurring (Productivity Development Team, 2003). Bicheno (2004, pp., p14) and Shinkle (2005) found that the careful pre-design of shop floor processes can prevent waste being generated on the shop floor. For instance, Toyota uses various tools and techniques to prevent waste (e.g., *kanban* for JIT), reduce variation (e.g., *judoka*, Japanese for stopping automatically) and increasing product quality (e.g., *Poka-yoke*, Japanese for error-proofing) (NKS and Factory Magazine, 1987; Ohno, 1988a, pp., p60; Womack *et al.*, 1990; Soltero and Waldrip, 2002). Therefore, the waste removal contains following three important steps for continuous improvement (Table 3.6).

Implementation of waste removal for *Kaizen*	• Waste identification • Waste elimination • Waste prevention

Table 3.6 The three important steps in waste removal for continuous improvement

3.4 Standard Operations

Standard operations or “standard work procedures” support continuous improvement (Imai, 1997; Bateman and Brander, 2000). Their implementation not only reduces waste and product variation (Ohno, 1988a, pp., p41; Liker and Meier, 2006; Tamura, 2006), but also acts as "an integral part of *Gemba Kaizen* and provide[s] the basis for daily improvement" (Imai, 1997, p20).

In manufacturing industry, standard operations are defined as "rules and methods to produce quality products safely and inexpensively by the efficient arrangement of people, products, and machines" (Hirano, 1988, p102). They are "chosen out of many methods" (Ford, 1926, p82) to work as "the best solution[s]" (Masters and Moss, 1983, p70) among the other methods available to support stability and reduce variation (Bicheno, 2004).

Additionally, "standard operations are the mother of improvement", they are the result of "improvement after improvement" (Japan Management Association, 1985, p118). In particular, the 'almost identical' processes (standardised operations) are considered to be the backbone of shop floor processes, and also "the foundation for continuous improvement [*Kaizen*], [and] innovation [*Kaikaku*]…" (Liker, 2004, p148). Therefore, the implementation of standard operations is widely accepted to be another critical factor in supporting continuous improvement (Ohno, 1988a; Bateman and Brander, 2000; Tamura, 2006).

3.4.1 Implementation of standard operations

The process of standard operations is a key activity for creating effective work flow, improving product quality, and implementing improvement on the shop floor (Liker, 2004). The failure of standard operations "creates waste (*muda*), inconsistency (*mura*), and unreasonableness (*muri*) in work procedures and work hours that eventually lead[s] to the production of defective products" (Ohno, 1988a, p41). The control of standard operations requires a full understanding of time, materials and the details of the work under consideration (Taylor, 1911). This is supported by Ohno (1988a, pp., p22), Hirano (1988, pp., p102), Dennis (2007, pp.,p51) and Liker (2004), who all indicated that takt-time, standard stock-on-hand and work sequence sheets provide the basic information needed to perform standard operations (Table 3.7).

Basic elements	Definitions
Takt-time (different from cycle time)	The necessary time and information to produce a unit or a piece of product
Work sequence	The order of the process to produce(s)
Standard stock-on-hand	The minimum amount of stocks (and equipment) to produce the product(s)

Table 3.7 the three basic of standard operations elements, adopted from Ohno (1988a, p22)

Standard operations also require specific and clear instructions (Ohno, 1979; Ohno, 1988a). In this sense, detailed written information is crucial in ensuring the implementation of standard operations. In manufacturing industry, four types of standard worksheet (quality control sheet, production standard sheet, work standard sheet, and work procedure sheet) are commonly used to store the information for implementing standard operations (Tamura, 2006). These work sheets are commonly known as the Standard Operating Procedures (SOPs). They are the written instructions for all standard work procedures and they provide guidance to ensure that activities are conducted in a consistent way (Ohno, 1988a; Suzaki, 1993; De Treville *et al.*, 2005).

In many Japanese manufacturing companies, the *kanban* system is also used as the SOP (Ohno, 1988a) "which gives information concerning what to produce, when to produce, in what quantity, by what means and how to transport it" (Japan Management Association, 1985, p85). The following Table 3.8 illustrates a step-by-step guide to developing these standard worksheets with regard to controlling the implementation of standard operations.

Steps	Purpose
1	Determine the cycle time
2	Determine the production capacity
3	Determine the number of operators
4	Define the working procedures
5	Write the standard operations sheet

Table 3.8 The five steps of developing standard operating procedures (Bicheno, 2004)

3.4.2 The importance of standard operations for continuous improvement

Implementing standard operations is a method of translating all the specific shop floor requirements into a standard, or, in other words, devising the best way of performing daily manufacturing operations effectively (Ford, 1926; Imai, 1997). Therefore, implementing standard operations is considered to be the "sum of all the good ways" of performing various tasks (Ford, 1926, p82) "to improve the *status quo*" (Imai, 1997, p52). For instance, Toyota's management team would "freeze" the set of standards for performing a task once they had found the best working practice (Liker, 2004, p142).

In the meantime, however, the controversy over implementing standard operations has been widely discussed (Bessant and Francis, 1999). In particular, some postulated that using the 'best setting of standards' could conflict with the philosophy of continuous improvement (Ghalayini *et al.*, 1997).

In fact, the process of standard operations is not static (Japan Management Association, 1985, pp., p118; Bicheno, 2004). As Imai (1997, pp., p52) indicated, standard operations are not an unchanging processes. The objective of standardisation is "to introduce permanent improvements in work methods" (Freire and Alarco´n, 2002, p250), "meaning that future results are expected to improve from the (current) standard" (Liker and Meier, 2006, p115), as "there is no one [single] best way to do the work" (Dennis and Shook, 2007, p47).

Standardised and stabilised operations are not only the result of "improvement after improvement" (Japan Management Association, 1985, p118), but also a point of departure for the next improvement (Bicheno, 2004; Liker, 2004; Tamura, 2006). Ford (1926, p82) once claimed that "today's standardisation, instead of being a barricade against improvement, is the necessary foundation on which tomorrow's improvement will be based". Similar findings appear in a number of subsequent studies (Imai, 1997; Prajogo, 2000; Prajogo and Sohal, 2001), in which the authors also claimed that a regulatory standard is essential for implementing continuous improvement. In particular, a report from the Toyota Motor Corporation (1998, p32) indicated that implementation of standard operations "provides a consistent framework for illuminating opportunities for making [further] improvements in work procedures". This was supported by Liker and Meier (2006, p115) who postulated that the development of standardisation in Toyota is considered to be "a baseline for continuous improvement".

In a sense, there is an even closer link between the process of standard operations and the implementation of continuous improvement. Tamura (2006) found that Taylor's (1911) concept of 'separation of conception and execution' has limited the authority to develop and modify standard operations and has led to limited process improvement.

Therefore, greater flexibility in modifying standard operations results in a higher success rate in terms of implementing continuous improvement (Liker, 2004, pp., p148; Tamura, 2006).

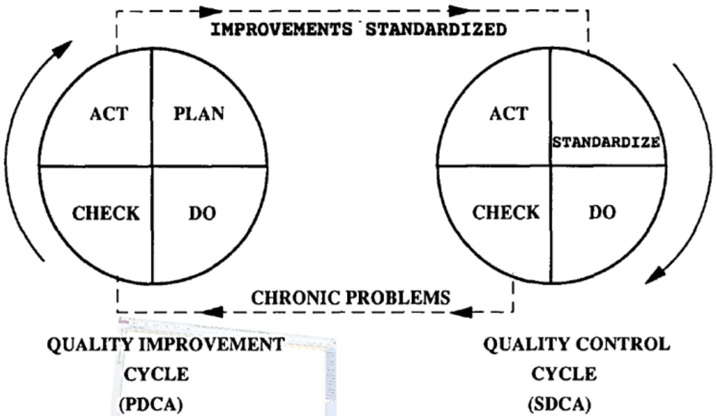


Figure 3.14 The symbiosis between maintenance and improvement (Wood and Munshi, 1991, p215)

Further evidence can be found in Imai's (1997) study, in which he recommended a model for implementing standard operations and continuous improvement, in which the two are not in conflict with one other. This model was developed based on the PDCA cycle (the Shewhart's plan-do-check-act Cycle), to control quality (Wood and Munshi, 1991) and continuously improve, standardise and stabilise processes (Imai, 1997; Prajogo, 2000). It has two cycles (SDCA and PDCA) (Figure 3.14). In this model, the SDCA (continuous standardise-do-check-act) cycle ensures that current standards are maintained, whilst the PDCA cycle looks for constant improvement (Figure 3.15).

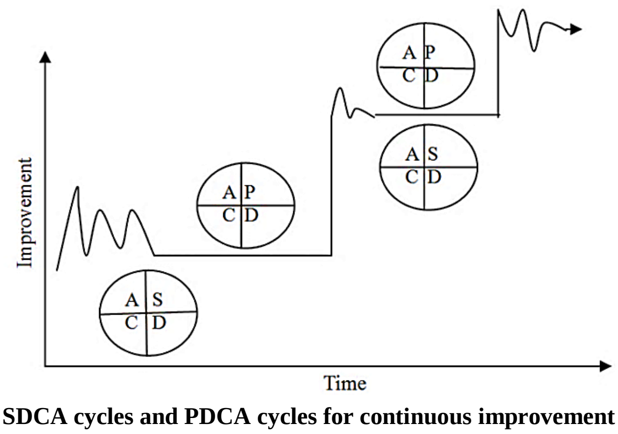


Figure 3.15 The SDCA cycles and PDCA cycles for continuous improvement (Imai, 1997, p53)

To sum up, the process of standard operations does not conflict with the improvement process (Ford, 1926; Liker, 2004). In fact, implementing standard operations is one of the building blocks to support continuous improvement (Bateman and Brander, 2000).

The following four types of standard worksheet (Table 3.9) are commonly used in standard operations to support continuous improvement (Tamura, 2006).

Use of the standard operations sheets	• Quality control sheet • Production standard sheet • Work standard sheet • Work procedure sheet

Table 3.9 The four standard work sheets in standard operation procedures (Tamura, 2006, p513)

3.5 Visual Management

Visual management (*mieruka* in Japanese, 目視管理) (Sekimura and Maruyama, 2006), visual control (*me-de-miru kanri* in Japanese) (Liker, 2004), or "management by sign" (Ohno, 1988a, p128) is another shop floor building block tool (Bateman and Brander, 2000) for the implementation of continuous improvement (Imai, 1997).

Visual management is a standardised control system that uses visual communication devices to organise and enforce production on the shop floor (Liker, 2004). The idea behind visual management is simple: to manage and maximise shop floor operating information (Bicheno, 2004, p61) at a glance by simplifying communication (Hirano, 1988, pp., p174; Choudri, 2002; Dennis and Shook, 2007). Fujio Cho, president of the Toyota Motor Corporation, said: "Mr. Ohno was passionate about TPS. He said you must clean up everything so you can see problems. He would complain if he could not look and see and tell if there is a problem" (cited in Liker, 2004, p149).

A simple way to describe the result of implementing visual management is to make the working environment "easy to observe" (Japan Management Association, 1985, p76) and, "easy to understand" (Bateman and Brander, 2000, p243) and to "make [any] abnormalities visible to all employees…so that corrective action can begin at once" (Imai, 1997, p96). Liker and Hoseus (2008, pp., p311) supported this view and postulated that visual management should be used to simplify and clarify shop floor communication for all observers. Visual management is a system to monitor shop floor performance (Liff and Posey, 2004) and provide information that drives improvements (Ortiz and Park, 2011). It mainly has three important features to support improvement: (1) to make problems visible; (2) to post standards and (3) to set improvement targets (Imai, 1997).

3.5.1 The power of visual management

In manufacturing industry, the importance of communication and information management on the shop floor has been analysed as part of many studies (Schonberger, 1986; Mestre *et al.*, 2000; Moxham and Greatbanks, 2001; Parry and Turner, 2006). As Liker and Hoseus (2008, p311) indicated, “communication is integral to the daily functioning of the production system”. As a result, the method of controlling information flows on the shop floor has become a critical factor for production (Forza and Salvador, 2001) and improvement (Ho, 1997). In particular, accurate (Fujimoto, 1999) and effective (Liker, 2004, pp., 244) communication methods are essential in creating the effective and efficient information flows (Mestre *et al.*, 2000).

Based on some empirical research, visual management methods have a good reputation for controlling information flows on the shop floor. For instance, a study by Oakland (2001) showed that visual methods are the most effective communication methods (Table 3.10), hence, they could result in better information flow on the shop floor. An in-depth study by Moxham and Greatbanks (2001, p411) reinforced this point by promoting the benefits of visual management methods on the shop floor. They indicated that the control of information flows by other communication methods (e.g., verbal methods) is “more time-consuming, often duplicated and subject to forgetfulness”.

Ranking	Communication methods
1st	Sight (visible)
2nd	Hearing (audible)
3rd	Feeling (tactile)
4th	Smell (olfactory)
5th	Taste (gustatory)

Table 3.10 The five senses contribute to the information flow, adopted from Oakland (2001, p199)

In Japan, visual management is part of the management culture (Liker and Hoseus, 2008) and has become “an integral part of the management process” (Mestre *et al.*, 2000, p35). The wide use of visual management for shop floor communication has achieved worldwide renown, not only for its accurate and rapid transmission of information (Hino, 2006), but also because of its use in encouraging shop floor employees to continuously increase productivity (Mestre *et al.*, 2000) and improve production processes (Imai, 1997). For instance, implementing visual management is more than just putting a chart or graph on the shop floor to show production goals (Parry and Turner, 2006). It is also a powerful tool for solving production problems (Liker and Hoseus, 2008) and improving the value-added flow of production (Liker, 2004).

Visual communication is one of the main foundational tools of the TPS (Liker and Hoseus, 2008). In particular, visual management is highly "integrated into the process of the value-added work [in Toyota]" (Liker, 2004, p152) and "embedded deeply in the culture of Toyota" (Liker and Hoseus, 2008, p311).

3.5.2 Implementation of visual management for continuous improvement

The use of visual control has proved to be the most successful method for communication on the shop floor. In Japan, visual management has been used in conjunction with 5S practice in pursuit of continuous improvement (Hirano, 1993; Hirano, 1996; Hemmant, 2007; Gapp *et al.*, 2008).

Visual management tools were categorised by Mestre et al. (2000) (Table 3.11). They were used in conjunction with one another and were integrated with other shop floor management tools to support continuous improvement (Hirano, 1993; Hirano, 1996; Hemmant, 2007; Gapp *et al.*, 2008).

Visual Com. types	Associated purposes	Tools
Workplace artefacts	To develop group identity, as well as inform, motivate and remind	Pictorial, graphical and colour-based signs, story boards, flip charts, banners, television, monitors, posters, billboards, information boards, murals and cartoon-filled manuals
Personal artefacts	To signify personal association and commitment	Uniforms, arm bands, buttons, lapel pins, protective eyewear, caps, jackets, jewellery and other features appertaining to clothing and personal appearance
Proxemic (shop floor layout) cues	To convey lines of authority and demarcate territorial boundaries	The layout of the company's external grounds, marks of the roads, buildings and their design, as well as arrangement of furniture
Personal and corporate rituals	To regulate internal dynamics, establish group solidarity and provide social support	Eye contact, facial expression, eating, drinking, smoking, and group activities

Table 3.11 The different communication types in visual management (Mestre *et al.*, 2000, p37)

According to the studies by Liker (2004), Choudri (2002) and Hino (2006), the most common visual management methods are visual indicators. These include *andon* (行灯), *kanban* (看板) and a wide range of graphs and charts (e.g., pictorial, graphical and colour-based signs, story boards, flip charts, banners, television broadcasts, monitors, posters, billboards, information boards, murals and cartoon-filled manuals) (Japan Management Association, 1985; Mestre *et al.*, 2000, p37). They are normally used as measurement tools to visually indicate different kinds of information on the shop floor (e.g., standards of the production) and as communication tools to transmit company production plans downwards to shop floor employees (Mestre *et al.*, 2000; Gapp *et al.*, 2008). In particular, the Japanese tools of *andon* and *kanban* are now widely used by many non-Japanese manufacturing companies (e.g., Saturn and Renault) for displaying the location of problems (*andon*) and transferring production information (*kanban*) (Imai, 1997; Mestre *et al.*, 2000; Fujimoto and Takeishi, 2001; Liker and Meier, 2006).

Furthermore, a special type of visual control method has been found on the Toyota shop floor: namely, the Toyota A3 problem-solving process report (Jackson, 2006; Liker and Meier, 2006; Dennis and Shook, 2007). This is a single sheet of A3 (11″ x 17″) size paper that includes a concise summary of the production information (Radeka, 2007). It was developed by Toyota for problem solving, proposal writing and summarising status (Liker, 2004; Liker and Meier, 2006; Liker and Hoseus, 2008). The essential aim of the A3 problem-solving process report is to "communicate information effectively" (Liker and Meier, 2006, p383).

The A3 problem-solving process report replaced the previous reporting system, which was bulky and lacking in standards (i.e., the reports were always too long and the formats often varied from one to another) (Dennis and Shook, 2007). Nevertheless, the A3 problem-solving report is a rigorous full report rather than a simple memo (Liker, 2004). It systematically records a process (Jackson, 2006) or addresses a problem (Jimmerson *et al.*, 2005) using only essential and absolute information (Table 3.12) (Radeka, 2007).

1. Theme (thesis at the top of the form stating the problem or challenge) 2. Problem statement (including an initial current state) defining the motive of the project 3. Target statement (or future state) defining the scope of the project 4. A scientific process (PDCA, i.e., scientific) process of investigating the problem 5. Systematic analysis (5 whys, cost benefit, cause-and effect diagram, design of experiments, ect.) 6. Proposed solution (including any cross-functional coordination of resources) 7. Implementation timeline (including the action, responsible parties, and deliverable data of the action) 8. Graphic illustrations to convey information at a glance. 9. Data and reporting unit or owner at the bottom of the form (the individual or team responsible for this particular A3).

Table 3.12 The nine typical elements within a A3 problem-solving report (Jackson, 2006, p8)

The implementation of the A3 problem-solving process report is closely incorporated into the PDCA cycle (Liker, 2004; Jackson, 2006) (Figure 3.16). It is designed for recording all communication functions for an improvement activity (Liker and Meier, 2006). It is also used as a developmental tool to take feedback from the operational level upwards (Liker and Hoseus, 2008); and as a policy deployment (*hoshin kanri*, 方針管

理) tool to disseminate details of the development plan downwards throughout the company (Jackson, 2006).

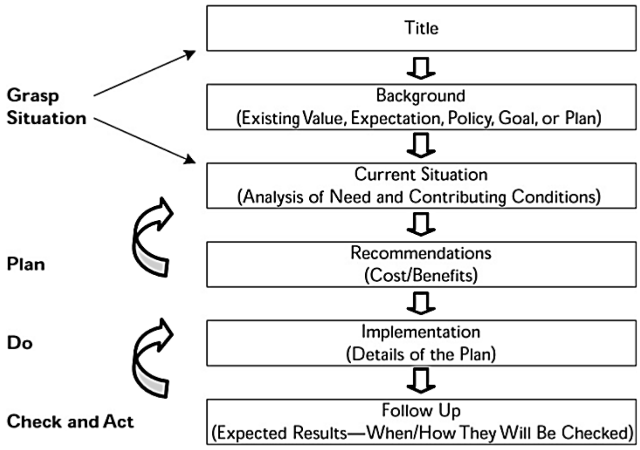


Figure 3.16 The PDCA Cycle in the A3 process report, adopted from Liker (2004, p247)

Use of visual management for *Kaizen*	• Visual indicator • Visual signal • Visual control • Guarantee

Table 3.13 Four types of visual management devices by Dennis (2007, p33)

In sum, visual management commonly involves four devices (Table 3.13) (Dennis and Shook, 2007, pp., p33) for improving the value-added flow of production (Liker, 2004). *Firstly*, visual management is used as an *Indicator* for displaying production information (e.g., production standards and targets) (Parry and Turner, 2006) and communicates working standards to the shop floor workers (Liker, 2004). The visual indicator can also be used for securing and maintaining corporate identity (Mestre *et al.*, 2000) and motivating employees (Liff and Posey, 2004). Visual management has been said to have "one of the most powerful effects" on motivation (Imai, 1997, pp., p96, p101). *Secondly*, use of visual management as a *Signal* to implement mutual communication between shop floor employees and their managers (Mestre *et al.*, 2000). This method acts as a two-way transfer of information between operational and managerial levels (Imai, 1997, pp., p96; Bicheno, 2004). *Thirdly*, implementing visual management, as a dynamic *Control System*, provides instant feedback and predicts a probable outcome on the shop floor (Parry and Turner, 2006). Thus, it helps to enforce discipline and teamwork amongst shop floor employees (Hirano, 1993; Liker, 2004). *Fourthly*, visual management can be used as a *Guarantee Mechanism* on the shop floor to ensure product quality (Langfield-Smith and Greenwood, 1998) by clearly displaying the location of the problem (e.g., *andon*) (Detty and Yingling, 2000; Parry and Turner, 2006). It also motivates employees to standardise their operations (Alfnes and Strandhagen, 2000; Liker and Meier, 2006) and looks for further process improvements (e.g., A3 report) (Liker and Hoseus, 2008).

3.6 Summary

This chapter has critically evaluated four building block shop floor management tools which were highlighted in Bateman and Brander's (2000) research. In particular, each of these building blocks has been analysed in detail taking into account their functionality, implementation method and their interrelationship during implementation.

The analysis of the literature in this chapter helped to shed light on these four building block tools and how they support continuous improvement. The analysis additionally worked as a prerequisite for later company visits and studies to examine and compare how *genba kanri* operates in different contexts to sustain process improvement on a continuous basis.

The next chapter introduces the research setting and explains the rationale for selecting the case study companies for the research. It also proposes a theoretical model and the research hypotheses.

Chapter 4 Research Design and Research Sites

This chapter describes: the research design; the selection of the research sites; and the development of the research questions. Section 4.1 summarises the characteristics of the *Kaizen* practices. Section 4.2 provides a brief historical review of the Chinese automotive industry and automotive joint ventures in Guangdong province. Section 4.3 describes the case study companies and how they were selected. Section 4.4 describes the findings of a preliminary study from one company, the research settings and the development of the research hypotheses.

4.1 Research Design

Following the discussion on the two Japanese *Kaizen* practices and their relationships as described in the literature, three of the underlying characteristics of *Kaizen* can be summarised:

- *Kaizen* involves everyone in the organisation, and aims to produce small and incremental changes over the long-term (Imai, 1986; Sheridan, 1997; Laraia *et al.*, 1999; McNichols *et al.*, 1999; Bateman and David, 2002);
- *Kaizen* consists of two important practices (QCCs and *Teians*) which are used to collect and implement all sizes of improvement ideas (Onglatco, 1985; Ghosh and Song, 1991; Tamura, 2006; Aoki, 2008; Liker and Hoseus, 2008; Marin-Garcia *et al.*, 2008); and
- *Kaizen* must be based on the support of shop floor management (Malaise, 1995; Handyside, 1997).

Hence, the current research postulates that there is a strong relationship between the individuals' application of shop floor management tools and the performance of *Kaizen*, measured in terms of the number of improvement ideas submitted, implemented and the rate of long-term implementation.

This research has been designed to explore and describe the situation with regard to adopting and utilising these tools for implementing continuous improvement. Accordingly, the following research objectives were developed:

- *To define the roles of QCCs and Teians in Kaizen;*
- *To describe the implementation of the building block shop floor management tools;*
- *To demonstrate the importance of shop floor management tools in supporting Kaizen;*
- *To explore the relationships between the Kaizen practices, shop floor management tools, and their long-term outcomes;*
- *To have a better understanding of Kaizen implementation in companies located outside of Japan*. These findings will be translated into actionable methods for practitioners to select the right practices to effectively collect and implement improvement ideas for long-term continuous improvement;
- *To provide an empirically tested model for studying and managing the Kaizen practices*. These findings will be used to refine the model for implementing shop floor management to support continuous improvement.

The research questions were:

1. What is the Japanese *Kaizen*? How does it differ from other improvement systems?
2. What are QCCs and *Teians*? How do these two practices differ from each other in collecting improvement ideas?
3. What is the relationship between these two *Kaizen* practices? Are they mutually inclusive and supporting of each other? If not, how do they impact on each other?
4. How can the practices of the Japanese *Kaizen* be adopted and implemented to sustain long-term continuous improvement?
5. What are the building block shop floor management tools? In what sequence should they be implemented?
6. In what ways are the shop floor management tools inter-dependent with the *Kaizen* practices? Can they be implemented independently of each other to support the *Kaizen* practices?
7. What is the relationship between these two *Kaizen* practices and their outcomes?
8. How can these practices produce better outcomes and sustain long-term continuous improvement?

4.2 Site Selection for This Research

The work was based in China for two main reasons: *first*, China has a fast-growing automotive industry. Since 2009, China has been the world's leading producer of vehicles in terms of volume. It is also the largest market for automotive products (see OICA, 2012). China has been a major recipient of capital investment from automakers including: Ford, GM, VW, Toyota, Honda, Nissan and many others, which have developed local production facilities (Webb, 2003; Friedland, 2012). *Second*, China is the most popular outsourcing destination in the world. Many major Japanese car assemblers and their parts suppliers have established joint venture relationships with Chinese companies to establish production facilities in China (Calantone and Zhao, 2001). They have transferred advanced production technology, management knowledge and improvement skills to the Chinese ventures (Lee, 1996; Tamura, 2006).

4.2.1 A brief historical context of the Chinese automotive industry

In 2009, China surpassed the U.S. and Japan to become 'the world's largest automotive manufacturer' (Figure 4.1) (Chin, 2010; China Automotive Industry Yearbook, 2011), It is poised to produce more cars than Europe in 2013 (Marsh *et al.*, 2013). However, the Chinese have a relatively short history of car-manufacturing in comparison with Western countries and Japan. The automotive industry in China was established in the late 1950s (Norcliffe, 2006). Two Chinese automotive companies, the First Automotive Works (the FAW) and the Dongfeng Motor Corporation (the DMC), were established in 1953 and 1969 respectively (Zhang, 2006). They were commissioned by Chairman Mao Zedong, and financially and technically supported by the former Soviet Union to mass produce trucks for the local market (Wang, 2003; Zhao, 2006).

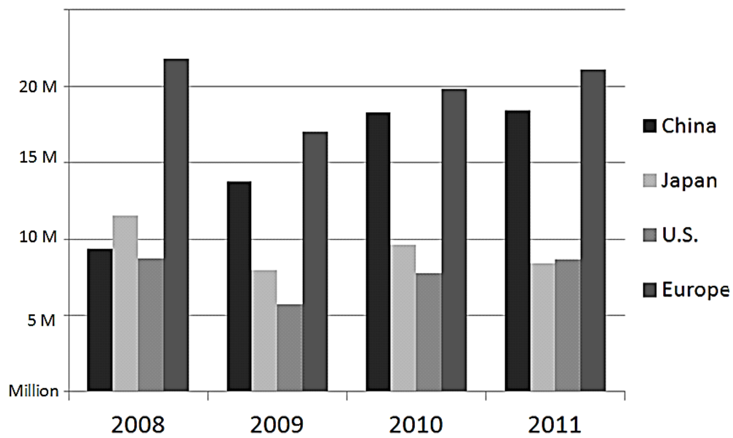


Figure 4.1 Vehicles Production (OICA, 2012)

In the 1980s, after the market reform policies had opened the Chinese markets, the disposable income of the Chinese population has maintained an upward trend (Xiao, 2003). From the late 1980s, the Chinese population became more affluent, contributing to the increasing number of people owning private vehicles (National Bureau of Statistics of China, 2008; Chinese State Council, 2010). The local demand for private vehicles, especially passenger cars, has increased dramatically (Harwit, 1995; China Automotive Industry Yearbook, 2011). Since the 1990s, more and more local automotive companies have been established (Jiang *et al.*, 2005; OICA, 2012).

In the 2000s, after half a century of development, China is home to almost as many automotive companies as the combined total of Japan, Europe and America (OICA, 2012). Many foreign automotive companies have set up partnerships with Chinese companies (Calantone and Zhao, 2001; Jiang *et al.*, 2005). In 2010, the Chinese car market was dominated by Sino-international joint ventures (Table 4.1) (Lee, 1996; Chen *et al.*, 1997). These foreign world-class automotive manufacturers (i.e., Volkswagen, General Motors, Jeep, Ford, Toyota, Nissan, etc.) not only established their production facilities in China, but also transferred their advanced production technology, management knowledge and improvement skills to the joint venture firms (Zhang and Alon, 2010, p. p41). In particular, Lean Production, shop floor management and *Kaizen* have been widely adopted and implemented in the Chinese automotive industry (Xing, 2010).

No.	Company name	Type of ownership	Location
1	FAW-Volkswagen Automotive	Joint venture	Changchun
2	Shanghai-Volkswagen Automotive	Joint venture	Shanghai
3	Shanghai General Motors Company Limited	Joint venture	Shanghai
4	GAC-Toyota	Joint venture	Guangzhou
5	Chery Automobile	Private	Wuhu
6	Dongfeng Nissan Passenger Vehicle Company	Joint venture	Wuhan
7	Beijing Hyundai	Joint venture	Beijing
8	Chang'an Ford Mazda Engine	Joint venture	Nanjing
9	Geely Automobile	Private	Hangzhou
10	Tianjin FAW Toyota	Joint venture	Tianjin

Table 4.1 The top ten Chinese car manufactures in 2007 (Zhang, 2008)

4.2.2 The Guangdong automotive manufacturing base

China has developed eight major automotive manufacturing bases (Table 4.2). In 2009, Guangdong was rated the number four in terms of vehicle production (1.7 million) and numbers of employees (0.3 million) (Li, 2010; China Automotive Industry Yearbook, 2011). Guangdong is home to three major Sino-Japanese joint venture car assemblers (they all have a strong connection with Nissan, Honda and Toyota) and over five hundred suppliers (Barkholz and Bolduc, 2008; China Automotive Industry Yearbook, 2011). These joint ventures and their tiered suppliers have adopted Lean Production and implemented *Kaizen* to support their daily production and improvement activities (Lee, 1996).

Annual production rate ranking (2007)	Major automotive manufacturing bases	Major car plants
1	**Shanghai**	General Motors, Skoda, and Volkswagen JVs
2	**Beijing**	Beijing Automobile Works, Beiqi Fonton Hyundai and Benz-Daimler Chrysler JVs
3	**Jilin**	Chang'an and Ford, Mazada and Suzuki JVs
4	**Guangdong**	Honda, Nissan and Toyota JVs
5	**Hubei**	Liuzhou Wulin Motors and GM JV
6	**Chongqing**	Dongfeng and Honda JV
7	**Guangxi**	FAW and Volkswagen JV
8	**Anhui**	General Motors and Volkswagen JVs

Table 4.2 The eight major Chinese automotive manufacturing bases (Chinese State Council, 2010)

The current research was set in this region. The research domain was the population of Sino-Japanese joint ventures at sites with experience of implementing Lean Production, shop floor management and continuous improvement.

4.2.3 The selected companies

Nine companies from Guangdong were selected. These companies were chosen based on the criteria:

- the data from the company had to be measurable, demonstrable, and replicable;
- the company should be in the automotive sector;
- the company had to be either a Japanese-owned company or a Japanese joint venture (in order to test a manufacturing practice which originated in Japan); and
- the company was prepared to divulge information to assist the research.

The selected companies were the leading automotive Sino-Japanese joint ventures. The companies are headquartered in Guangzhou (or Canton, the capital city of the Guangdong Province). They have joint venture relationship with several Japanese partners to produce Japanese branded cars, buses and automotive parts/components for sale in China. Since the Japanese had invested in the companies, changes are taken place gradually, such as the introduction of the advanced production technology, management knowledge and improvement skills. At the time of this study, the employees throughout the companies have participated actively in their improvement practices.

Company	Main Products	Establishment of Joint-venture	Annual production capacity (m=million)	No. of employees
Com_1	Cars	09/1998	0.60	6500
Com_2	Air conditioners	06/2003	0.56	750
Com_3	Door trim panels	09/1999	0.36	300
Com_4	Car seats and carpets	09/2004	0.4	200
Com_5	Aluminium alloys	08/2004	0.24 (tons)	200
Com_6	Seat covers	12/2005	0.5	250
Com_7	Sound insulators	08/2005	0.4	300
Com_8	Radiators	11/1994	0.33	700
Com_9	Windshield wipers	11/1999	1	500

Table 4.3 The case study companies (2009)

As shown in Table 4.3, the selected companies included one major car assembler (**Com_1**) and eight smaller automotive parts/components producers that are first-tier suppliers (**Com_2** to **Com_9**). All of these selected companies had experience of implementing Lean shop floor management tools and continuous improvement (Table 4.4). Hence, they were ideal for exploring the relationship between Genba Kanri and continuous improvement.

Com	Experience of *Kaizen* (2009)	*Teians* (per person per month)	QCCs		
			Time span	No. of members involved	Source of the members
Com_1	7 Years	Minimum of 1[1]	3-6 months	6-12	Not specified
Com_2	5 Years	No minimum requirement [2]	6 months	7-15	Same shop floor
Com_3	5 Years	Minimum of 1	Not specified	Not specified	Different shop floor
Com_4	5 Years	No minimum requirement[3]	6 months	5-15	Same shop floor
Com_5	5 Years	Minimum of 1[2]	6 months	5-15	Not specified
Com_6	1 Year	No minimum requirement	3-6 months	Not specified	Same shop floor
Com_7	1 Year	Minimum of 1	6 months	5-10	Not specified
Com_8	5 Years	Minimum of 1*	3-6 months	4-12	Not specified
Com_9	5 Years	Minimum of 1	3-6 months	6-12	Not specified

Teians can be submitted either online or in a paper-based format.
Shop floor management theory: *Genchi-Genbutsu* (Japanese for 'go to see the place and collect the data from where the problem is occurring').
Financial incentive: *Teians* reward based on participation, QCCs reward based on outcome
[1]*Teians* for environment, creative, safety or cost.
[2]*Teians* for cost or quality.
[3]*Teians* for quality only.
**Teians* can only be submitted in a paper-based format.

Table 4.4 the *Kaizen* implementation in each of the selected case companies

Com_1 is a car assembler whose headquarters is based in Guangzhou. The company operates as a 50:50 Sino-Japanese joint venture to assemble Japanese-branded automobiles. The origin of the Company dates back to the early 1990s when it was a state-owned company that only produced motorcycles. In 1994, the company expanded its production capabilities and began producing parts for cars. The company became a joint venture in 1997 with a world leading Japanese car firm; a new assemble line was set up and production started in 1998. Today, **Com_1** is one of the leading car assemblers in China. It has two plants and two assembly-lines, covering a land area of approximately 2 million square metres, that produces five types of automobile. The annual production capacity is more than half a million units. It employs over 6000 employees, of which 25% are graduates. **Com_1** has been extremely successful in implementing Lean and collecting ideas from employees to support *Kaizen* (**Section 4.3**).

Com_2 was established as a Sino-Japanese joint venture in 2003. It is in partnership with a global leading provider of automotive components. It manufactures and supplies air conditioners and radiators to car assembly companies. **Com_2** values the principles of *Kaizen*, collaboration and team working as well as the need for shop floor management as a basis for effective problem solving. In 2009, the company had 5 years of experience in implementing both QCCs and *Teians* to collect ideas based on the fundamental behaviour of *Genchi-Genbutsu* (Japanese for 'go to see the place and collect the data from where the problem is occurring').

Com_3 was founded in 1999 jointly by a Chinese car components manufacturer, a Japanese technology company and a Japanese manufacturing company. The joint venture is located in Guangzhou Economic & Technological Development District, and covers an area of over 40 thousand square metres. **Com_3** produces internal trim panels, sun visors, etc., and is one of the first tier-suppliers of **Com_1**. In order to produce parts with high quality standards, **Com_3** has adopted the improvement practices of **Com_1**. It has helped the company to underpin *Kaizen* and encourage its employees to participate in long-term improvement activities.

Com_4 began manufacturing automotive interior trim in the late 1990s in Guangzhou and became a joint venture with a Japanese automotive interior trim producer in 2004. It supplies car seats and carpets to **Com_1**.

Com_5 became a joint venture in 2004. It is located in Nansha Development Zone with an area of 70 thousands square metres. The Company mainly produces aluminium alloys and ingots for **Com_1**. Since the establishment, the Company has been implementing *Kaizen*. It has encouraged the full participation of all employees in QCCs and *Teians*.

Com_6 and **Com_7** are both partners of the same Japanese automotive interior trim manufacturer and are located in the Guangzhou Yonghe Economic & Technological Development District. **Com_6** was established as a wholly foreign owned enterprise (WOFE) in the 1990s and changed to a joint venture in 2005 that produced car seats and seat covers. **Com_7** was founded as a joint venture in 2005 to make sound insulators. Both companies had less experience of implementing *Kaizen* than the other suppliers.

Com_8 was founded in the late 1980s and became a joint venture in 1994. The Company has a Japanese partner which is a leading global automotive components manufacturer. Its main products include shock absorbers, steering systems, gas springs and propeller shafts. **Com_8** has been operating for approximately 20 years and is now one of the preferred suppliers to Com_1.

Com_9 was founded in 1999 and located in the Guangzhou Development District. It was transformed into a joint venture in 2006 to manufacture windshield wiper systems, washer systems, door mirrors and lamps. The company mainly supplies windshield wipers to **Com_1** and has gained experience from its Japanese partner in implementing a continuous improvement programme. In particular, the improvement programme from **Com_9** focuses on collecting ideas that derived from employees' daily shop floor experience.

4.3 A Preliminary Study and The Development of Research Hypotheses

A preliminary study was conducted in **Com_1** as an initial exploration of the research questions and objectives (Ma *et al.*, 2010). This company was chosen because it provided an opportunity and appropriate contect: it has relatively high production volume and substantial experience in implementing Lean Production, shop floor management and *Kaizen* (Table 4.3).

The findings from **Com_1** were mainly developed for three purposes: *first,* to develop a better understanding of continuous improvement in the selected site; *second,* to compare and contrast the findings of implementing continuous improvement from the practical study and those specified in the literature; *third*, to develop a theoretical framework and hypotheses.

4.3.1 The findings from the preliminary study

A triangulated method (Figure 4.2) was employed in the preliminary study to collect data from multiple sources including: documentation, archival records, informal interviews and conversations with the members of the company, and participate observation.

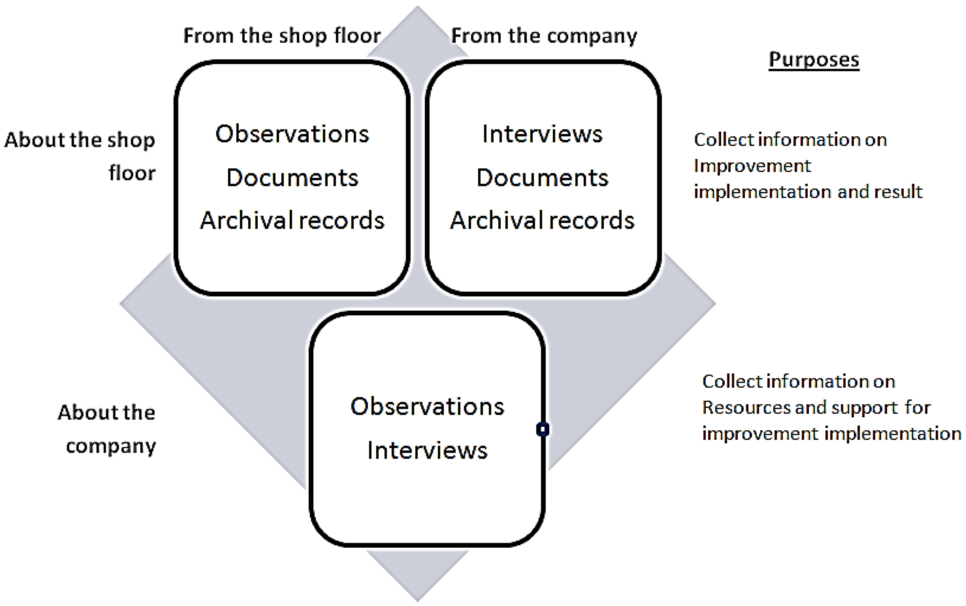


Figure 4.2 The triangulated data collection method for the preliminary studies

Informal (unstructured) interviews (Babbie, 2004; Saunders *et al.*, 2007) were conducted with 7 employees from **Com_1**. The interviewees included one production manager, two first line supervisors, and four shop floor operators. They all had been working in the company for a minimum 3-4 years, and many had been working in the joint venture since it was established.

Com_1 had implemented both shop floor management and *Kaizen*. The company had over 5 years experience of implementing shop floor management (Figure 4.3) to support their *Kaizen*.

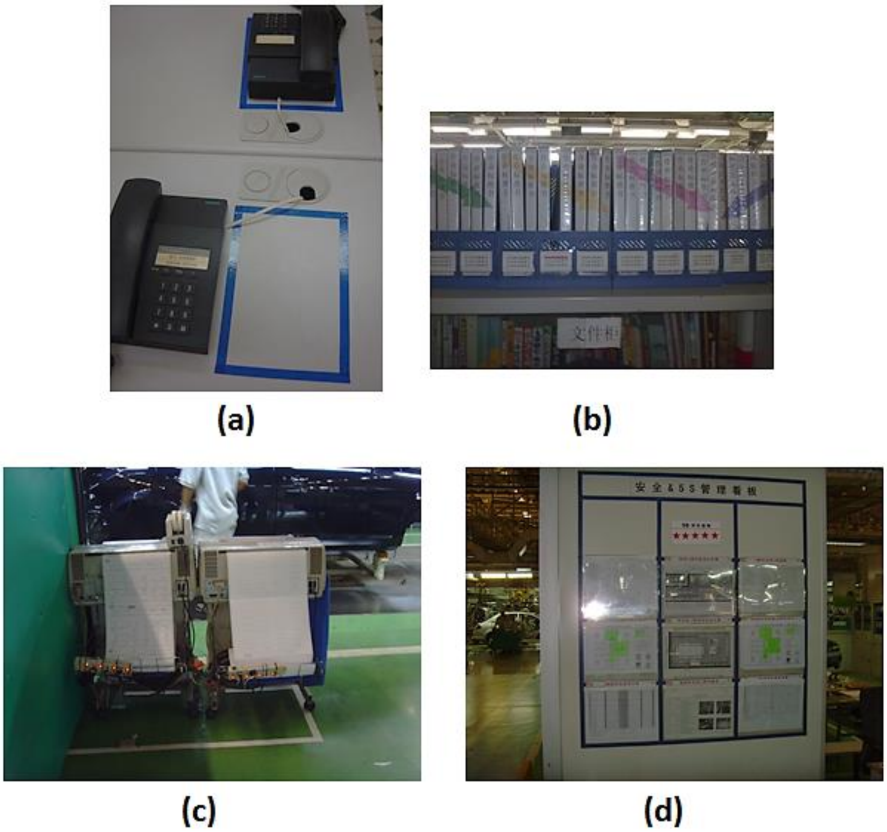
Figure 4.3 One of the safety checks on the shop floor, an example of shop floor management implementation

The preliminary study showed two important findings:

First: the company had extensively implemented shop floor management.

The development of improvement ideas in **Com_1** was strongly supported by several important shop floor management tools which include 5S, visual management and waste removal. They were applied extensively on the shop floor for housekeeping, to maintain shop floor cleanliness and safety (Figure 4.4).

In addition, **Com_1** had committed itself by providing training for employees in implementing shop flooring management tools and showing the importance of those tools to support continuous improvement. As a result, most employees received regular on- and off-the-job training on implementing standard operation procedures (Figure 4.5). The use of these tools formed the basis for the company's shop floor philosophy: '*Genchi Genbutsu*'. The idea of this is to develop a true understanding of the root cause of problems. It allows operatives to regularly detect problems and identify and implement solutions based on their shop floor knowledge, skills and experience.



(a) **The use of the 5S practice for placing the telephones**
(b) **The use of visual management to locate files and folders location**
(c) ***Kanbans*** **were being printed for JIT delivery to reduce waste**
(d) **The 5S practice promoting board on the shop floor**

Figure 4.4 Some examples of the implementation of shop floor management tools

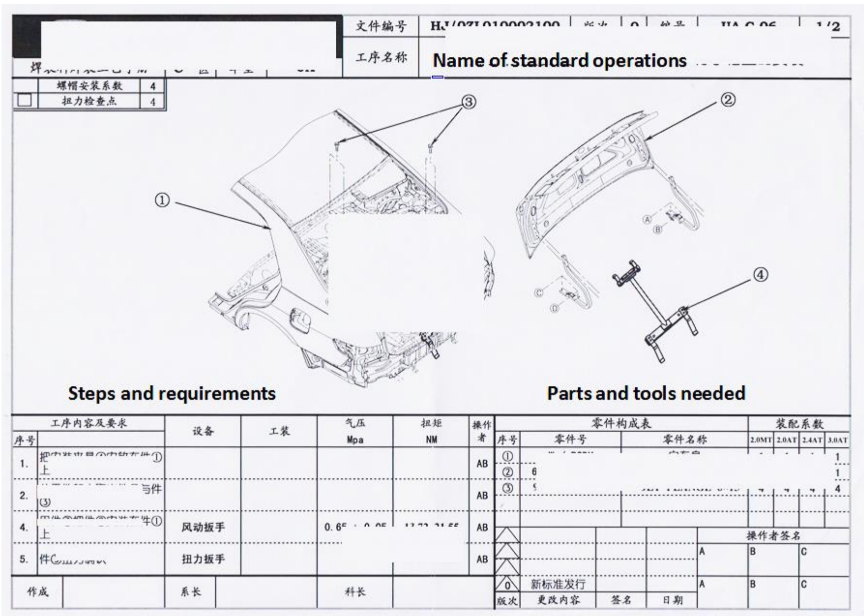


Figure 4.5 An example of a standard operations procedure card

Second: the company had implemented both QCCs and *Teians* for *Kaizen* (Table 4.5 and Table 4.6).

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008
QCC groups	39	87	175	296	473	571	665	970	1340
Participation rate (%)	12	30	45	65	79	85	86	93	89
Participants	264	623	1120	2085	3083	3642	4543	5425	5964
Presented QCC groups	16	24	26	36	36	36	42	52	65
Presented participants	80	710	750	790	900	930	1140	1450	1560

Table 4.5 The implementation of QCCs from the company archives

	2004	2005	2006	2007	2008
***Teians* submitted**	928	15591	15591	17368	23141
***Teians* implemented**	587	4467	9423	12952	17370
***Teians* resulted in savings > ¥m**	12	15	18	25	*

*Data not available in 2009

Table 4.6 The implementation of *Teians*from the company archives

Com_1 had policies to actively involve the all employees (including line supervisors and managers) to make improvement ideas in four areas, including environmental, creative safety and cost.

Figure 4.6 An example of a QCC meeting place (with memebrs picture display to increase attdence and promote teamwork)

In **Com_1**, The improvement practices existed alongside the shop floor management tools. The QCCs (Figure 4.6) were promoted for improving teamwork and communications (Figure 4.7). They were also implemented to identify large potential improvement opportunities (e.g., innovation and *Kaikaku*). *Teians* (Figure 4.8) were widely implemented to solve localised problems. They were routinely sought from employees. The practice provided a structure method to collect improvement ideas. Shop floor employees were required to hand in their *Teian* sheets on a monthly basis to track their improvement results.

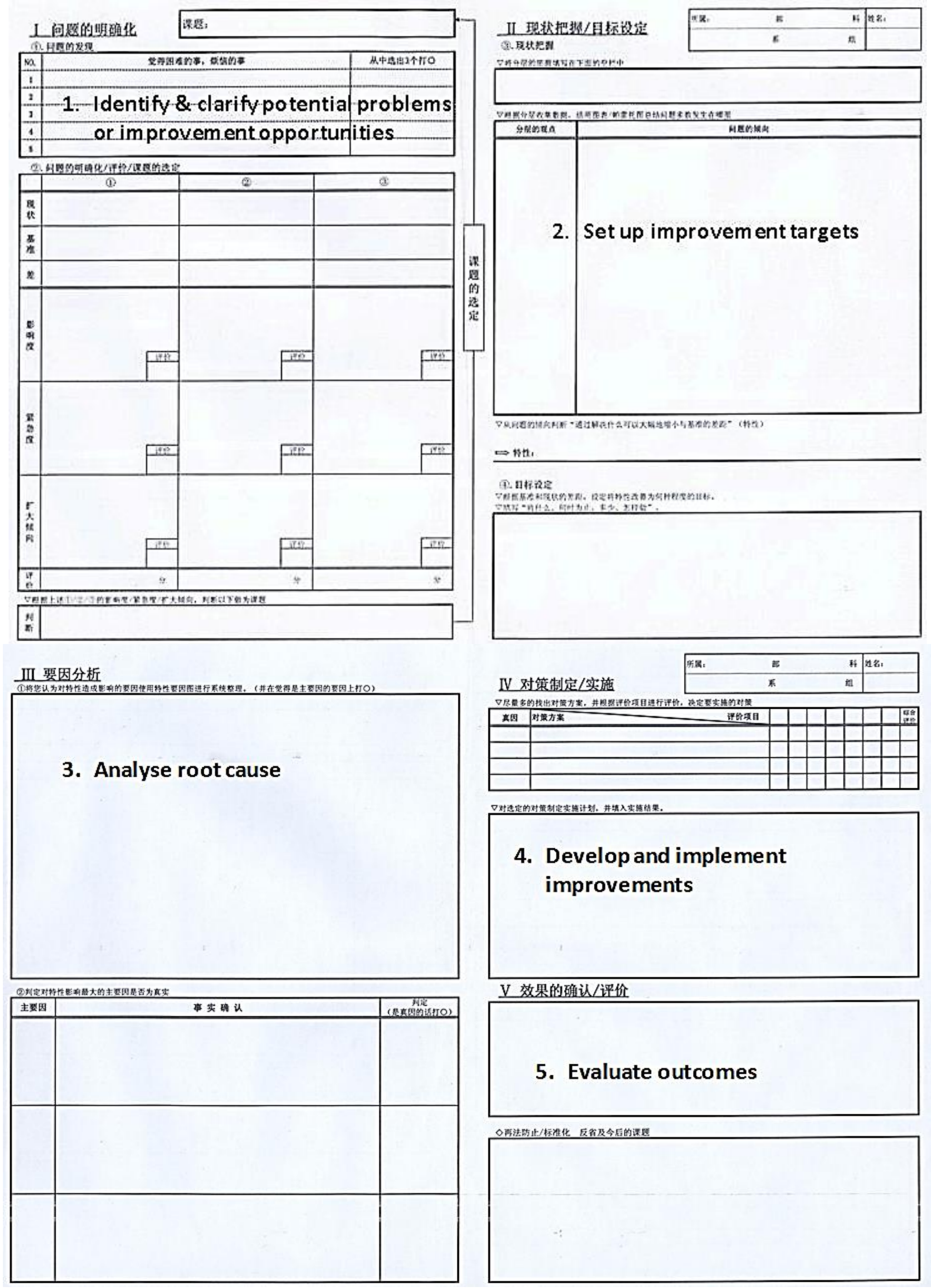


Figure 4.7 An example of a QCC improvement record card

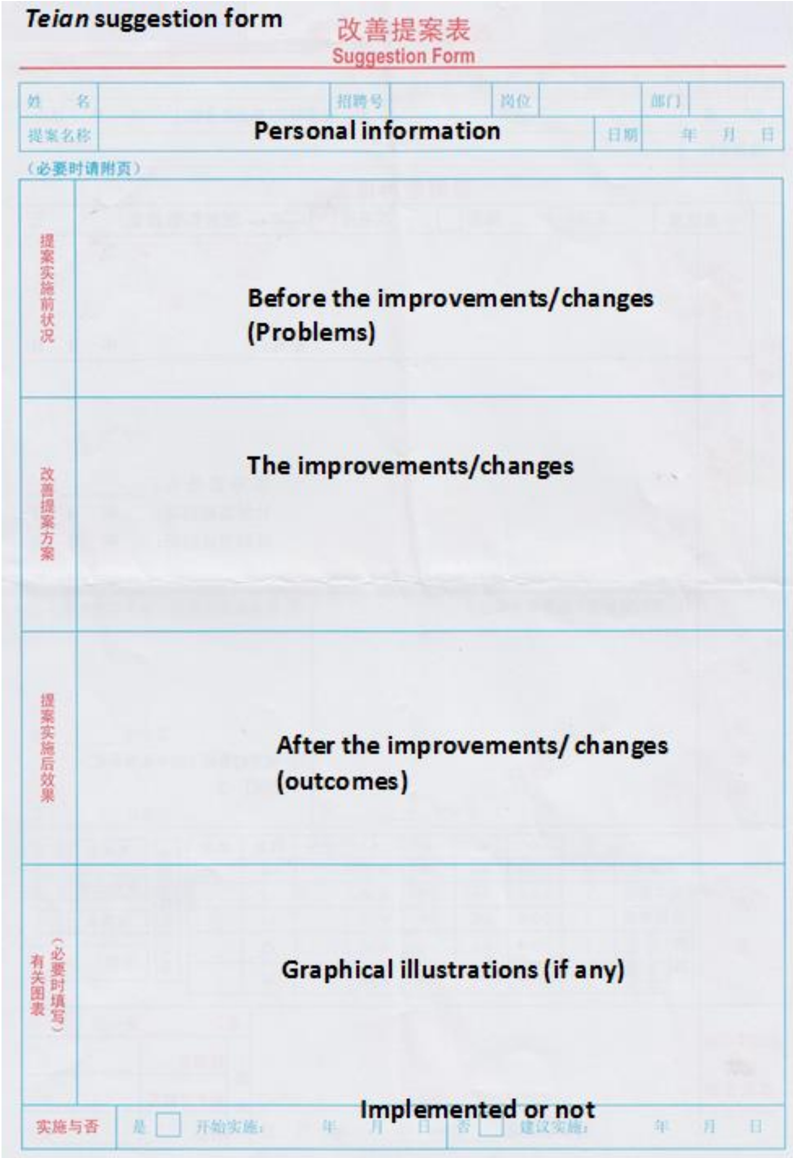


Figure 4.8 An example of a *Teian* suggestion form

These findings reaffirmed that *Kaizen* consists of two types of improvement practices: the individual schemes (*Teians*) and small group activities (QCCs). These helped to underline their importance and the close connections with 5S, waste removal, visual management and standard operations. These findings also helped to provide a better understanding of *Kaizen* in both theory and practice. They were later used to inform the development of the research hypotheses.

4.3.2 The development of the research hypotheses

In order to meet the above research objectives and answer the research questions, the current study was conducted as empirical research (Flynn *et al.*, 1990) to explore and investigate the relationships between individuals' implementation of the shop floor management tools, *Kaizen* and their associated outcomes. The following research hypotheses were proposed.

The following research hypotheses were proposed:

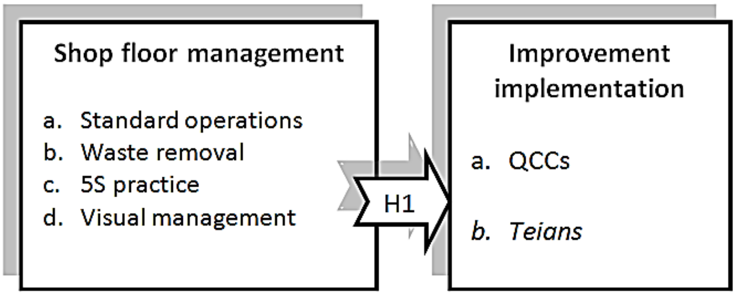


Figure 4.9 The hypothesised model (1)

H1. the building block shop floor management tools have positive effects on improvement practices (Figure 4.9);

H2. the two improvement practices are mutually supportive; and

H3. the two improvement practices have positive effects on the long-term outcomes (Figure 4.10).

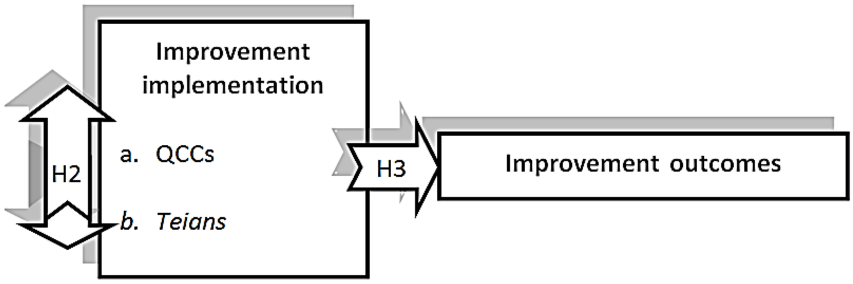


Figure 4.10 The hypothesised model (2)

4.4 Summary

This chapter has introduced the current research setting and explained the rationale for selecting the nine Sino-Japanese automotive joint ventures. These joint ventures were chosen from the region which is one of the most important automotive manufacturing bases. This region is famous for having three Sino-Japanese car assemblers (with a strong connection with Nissan, Honda and Toyota) and having the total annual production of more than one million. The selected companies included one car assembler and its eight first-tier suppliers. They were the leading Sino-Japanese joint ventures in the region. They were also chosen based on their high production volume and substantial experience in implementing Lean Production, shop floor management and *Kaizen*.

The next chapter introduces the research strategy and the methodology. It explains the design of the questionnaire and the development of the respective questions to measure the impact of the improvement practices.

Chapter 5 Research Methods

This chapter describes the methodology that was used in this research. The chapter is divided into 3 sections: section 5.1 describes the choice of the research strategy and the data collection techniques; section 5.2 introduces Factor Analysis to identify the most important factors; and section 5.3 explains Structural Equation Modelling.

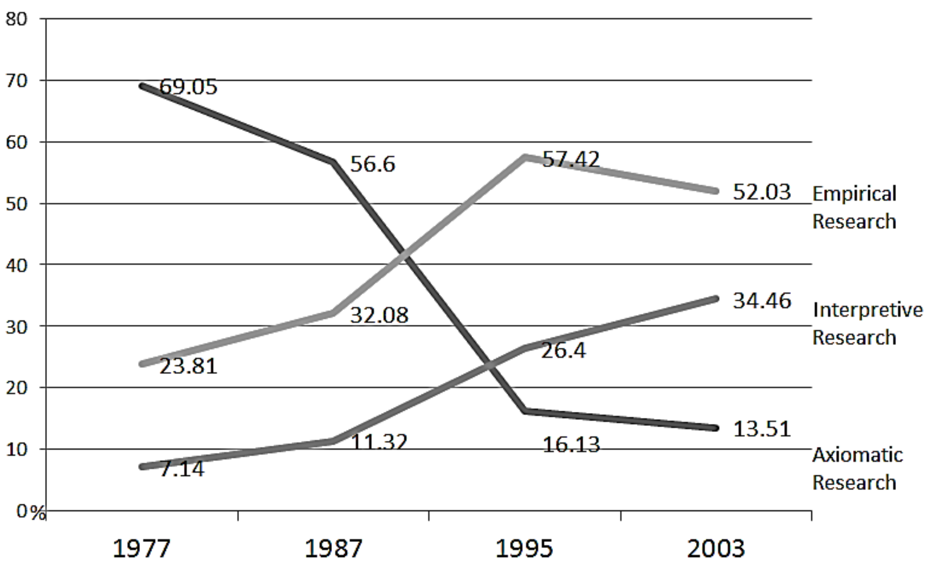
5.1 Research Process and Design in Operations Management Research

The academic research process is a methodical approach which involves procedures to design research, gather data as evidence, interpret and analyse the data, and make conclusions (Croom, 2009). Each research process has its own sequence of procedures and may follow different patterns (Gill and Johnson, 2010).

Operations management has been defined as “The activities, decisions and responsibilities of managing the production and delivery of products and services” (Slack *et al.*, 2007, p4). It has wide scope on the perspective of operations as transforming resources (Karlsson, 2009; Hill, 2012). Thus, operations management research is a broad field (Hensley, 1999), it may cover many issues and can be carried out using several different research designs (Karlsson, 2009) to collect and analyse the data (Yin, 2003b). Based on the source of data used and the approach taken to generate knowledge, operations management research may be broadly classified as axiomatic research, empirical research and interpretive research (Buffa, 1980; Meredith *et al.*, 1989; Wacker, 1998; Bertrand and Fransoo, 2002; Croom, 2009). Axiomatic research is a model-driven method (Stigum, 1990) using mathematical models (Meredith *et al.*, 1989) and ‘abstract’ data (i.e., assumptions or manipulated data rather than empirically observed data) (Croom, 2009) to improve existing study results or look for an optimal solution for a newly defined problem (Bertrand and Fransoo, 2002). Empirical research is a reality-driven (Bertrand and Fransoo, 2002) deductive method (Craighead and Meredith, 2008) using data gathered from naturally occurring situations (i.e., data derived from the field) to describe phenomena (Meredith, 1998) and identify causal relationships between relevant variables (Flynn *et al.*, 1990; Swamidass, 1991; Malhotra and Grover, 1998). Interpretive research is a reality-driven approach based on empirical data (Croom, 2009), but it tends to be more inductive and subjective (Meredith *et al.*, 1989). It is mainly used for descriptive studies (Prasad and Babbar, 2000) to understand how others construe, conceptualise and understand events and concepts (Craighead and Meredith, 2008).

5.1.1 Empirical research design

Empirical research can be described as "field-based research which uses data gathered from naturally occurring situations…" (Flynn *et al.*, 1990, p251), "… and subsequent reporting of findings and conclusions" (Minor *et al.*, 1994, p5). In addition, it has been widely used in the operations management field (e.g., Figure 5.1) (Vokurka, 1996; Filippini, 1997; Scudder and Hill, 1998) to explain the underlying phenomena and theories (Rungtusanatham *et al.*, 2003; Bayraktar *et al.*, 2007; Fisher, 2007). Thus, the field-based empirical research design might be adopted in the current study because: 1) this research belongs to the operations management filed; and 2) its purpose is to investigate the theoretical causal relationships between the application of shop floor management tools and the performance of *Kaizen*.



Journals: 1) *Management Science*, 2) *Decision Sciences*, 3) *Journal of Operations Management*, 4) *International Journal of Operations & Production Management*, 5) *Production and Operations Management*

Figure 5.1 The research designs used (in %) in 5 selected leading OM journals (Craighead and Meredith, 2008)

Empirical research can be used both for exploratory (theory building) and explanatory (theory verification/testing) studies (Flynn *et al.*, 1990). Given the nature of the research questions, this study is aimed at theory verification using an empirical research design to test causal models that can adequately describe the reality rather than building a theory.

5.1.2 Common empirical research strategies in operations management

According to Flynn et al. (1990), Scudder and Hill (1998), Wacker (1998), and Bertrand and Fransoo (2002), common empirical research strategies may include case study, survey, database study, panel study and focus group (Table 5.1).

Case study (the single/multiple cases)	The in-depth study of one or more examples from industry.
Surveys	The use of a collection instrument to determine the state of industry.
Database	The use of archival data, typically large databases, from which analysis is done to draw conclusions about the research.
Panel study	The use of a group of experts to obtain information about a topic in writing.
Focus group	Similar to a panel study, but the group is physically assembled and each response is given to the entire group orally, rather than in written form.

Table 5.1 Common empirical research strategies (Flynn *et al.*, 1990; Scudder and Hill, 1998; Saunders *et al.*, 2007)

Case studies and surveys (Table 5.2) are two of the most commonly used empirical research strategies in operations management research to obtain data for theory building and verification (Flynn *et al.*, 1990; Minor *et al.*, 1994; Scudder and Hill, 1998; Rungtusanatham *et al.*, 2003; Gimenez, 2005; Jiang *et al.*, 2007).

	Case (e.g., Case study)	Rationalist (e.g., Survey)
Advantages	Relevance Understanding Exploratory depth	Precision Reliability Standard procedures Testability
Disadvantages	Access and time Triangulation requirements Lack of controls Unfamiliarity of procedures	Sampling difficulties Trivial data Model-limited Low explained variance Variable restrictions Thin results

Table 5.2 Advantages and disadvantages of survey and a case study based on Meredith (1998, p443)

A case study research strategy (Yin, 2003b) is “a detailed examination of an event (or series of related events) which the analyst believes exhibits (or exhibit) the operation of some identified general theoretical principle” (Mitchel, 1982, p27). This strategy (Figure 5.2 and Table 5.3) concerns the context of discovery (McCutcheon and Meredith, 1993; Steenhuis and Bruijn, 2006), thus, it is mainly used for theory building and explorative study (Eisenhardt, 1989; Meredith, 1998; Voss *et al.*, 2002). It focuses on meanings and experiences of other people to deduce how they construe, conceptualise, and understand events and concepts (Meredith *et al.*, 1989; Lowenberg, 1993). This strategy may use multiple sources of evidence (Tellis, 1997; Yin, 2003b) either quantitatively (e.g., questionnaires, databases) or qualitatively (e.g., interviews, panel study, observations, documentary analysis) (Saunders *et al.*, 2007) to provide in-depth investigation into a particular contemporary incident (Yin, 2003a; Croom, 2009) or social phenomenon (Harrison, 2002; Babbie, 2004) within its real life or operating context (Cooper and Schindler, 2003; Yin, 2003b). Although this strategy could lead to new and creative insights and the development of new theory, the conclusions may only draw from a limited set of cases (Voss *et al.*, 2002).

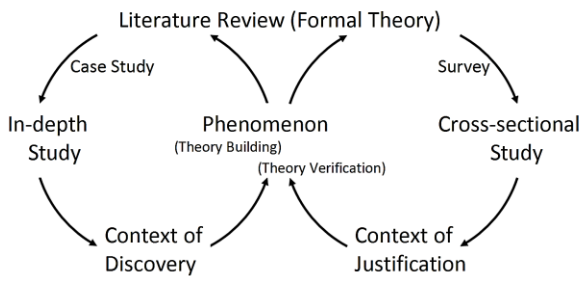


Figure 5.2 The different research cycles of a case study and survey based on Steenhuis and Bruijn de (2006)

	Case study	Survey
Orientation	Usually qualitative oriented	Usually quantitative oriented
Variables	Are often not predefined	Are predefined
Data collection	Using structured and unstructured formats (Financial data, interviews, memoranda, questionnaires, organisation charts, etc.)	Using a structured format (Questionnaire)
Results	In-depth examination of a phenomenon but not a generalization	Usually allows findings to be generalised from the sample to the population

Table 5.3 Main differences between case study and survey (Gimenez, 2005, p318)

A survey strategy (Fowler, 2002), in comparison, is a cross-sectional (Johnson and Duberley, 2000; Aldridge and Levine, 2001) quantitative approach (Malhotra and Grover, 1998). It collects geographically scattered samples (Scudder and Hill, 1998; Quinlan, 2011) that are representative of the whole population (Saunders *et al.*, 2007). It provides flexibility and accessibility in terms of time and distance for assessing information from a wide range of respondents (Miller and Salkind, 2002; Mitchell and Jolley, 2010). Therefore, a large sample size can be obtained which contributes to a greater confidence in the generalisability of the findings. Accordingly, this strategy (Figure 5.2 and Table 5.3) can be used to generalise a phenomenon (Bryman, 2004) based on the descriptive characteristics of the samples (De Vaus, 2002; Babbie, 2004). In addition, this strategy could also be used to make comparisons across situations (Bryman, 2004), test patterns of association (Bryman, 1992), and determine particular relationships (De Vaus, 2002) by using inferential statistics (Marczyk *et al.*, 2005). The survey strategy concerns the context of justification (Steenhuis and Bruijn, 2006), hence, it is commonly used for theory testing and theory extension (Meredith, 1998; Voss *et al.*, 2002).

A survey strategy was selected to collect data from the shop floor employees in the selected case companies, because the objectives were to: 1) provide a general description of the *Kaizen* implementation in Sino-Japanese joint ventures; and 2) test the hypothesised causal relationships between the application of shop floor management tools and *Kaizen*.

5.1.3 Data collection methods in the survey strategy

The survey strategy consists of popular methods (e.g., Figure 5.3) to collate information for business and operations management research (Zikmund *et al.*, 2010). In particular, interviews and questionnaires are the two main methods (Forza, 2002) which have been used to collect data (Oppenheim, 1992).

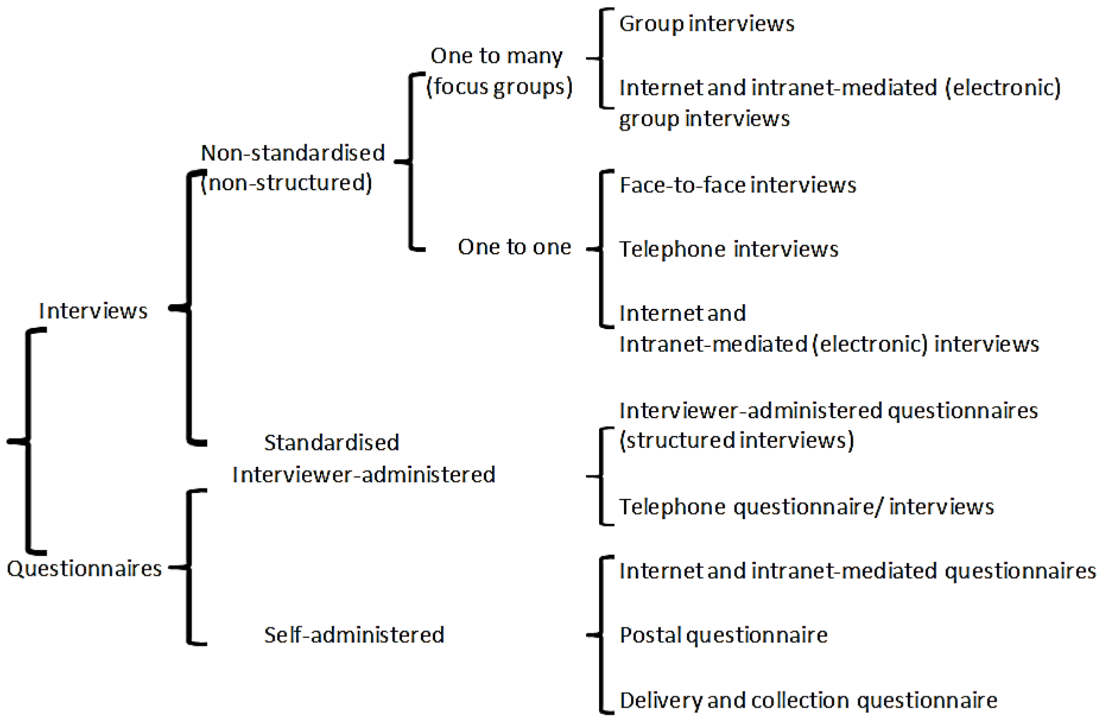


Figure 5.3 Forms of interviews and questionnaires, developed based on Saunders et al. (2007, p321 & p363)

An interview is “a purposeful discussion between two or more people” (Saunders *et al.*, 2007, p318), whereas a questionnaire is “a technique in which each respondent is asked to answer to the same set of questions in predetermined order" (Saunders *et al.*, 2007, p360). These two methods can be further divided into variety of ways (Figure 5.3), and some overlap each other (e.g., the structured interviews and the interviewer-administered questionnaires) (Oppenheim, 1992). As they have advantages as well as shortcomings (e.g. Table 5.4), decisions on the use of the methods should be based on the specific research (Forza, 2002).

Factors influencing coverage and secured information ('1' indicates the maximum strength, and '3' the minimum)	Non-standardised interviews (e.g., telephone survey)	Standardised interviews (e.g., personal interview)	Self-administered questionnaires (e.g., delivery & collection questionnaire)
Theory building	2	3	1
Theory verification	2	1	2
Cost	2	1	3
Response rate	2	1	3
Accuracy of information	3	1	2
Sample coverage (generalisability)	2	3	1
Completeness	2	1	3
Overall reliability and validity	3	1	2
Time required to secure information	1	2	3
Ease of securing information	2	3	1
Anonymity of the data	2	1	3
Respondents' convenience	2	3	1

Table 5.4 Comparison of data collection methods, developed based on Forza (2002, 167)

A self-administered questionnaire was selected to collect data. This method has at least 5 distinct characteristics: 1) it is commonly associated with the deductive approach (Saunders *et al.*, 2007) and appropriate for descriptive and theory-verification purposes (Oppenheim, 1992); 2) it reduces interviewer bias and assures anonymity of the data (Forza, 2002); 3) it can directly and systematically collect data (Forza, 2002) from a large number of shop floor respondents; 4) it has large-scale accessibility (Miller and Salkind, 2002) thus it can effectively and simultaneously collect data (Quinlan, 2011) from different case companies; and 5) it is a relatively easy, quick and low-cost (McNeill and Chapman, 2005; Mitchell and Jolley, 2010).

5.1.4 Overview of statistical techniques in empirical analysis

After the data collection, appropriate statistical techniques should be selected to analyse the data (Tabachnick and Fidell, 2007) and to study the relationships between the variables (Table 5.5). The domains of techniques may be classified as: univariate, bivariate and multivariate statistics.

Univariate statistics	Analyses in which there is a single variable (primary for descriptive statistics)
Bivariate statistics	Analysis of two variables simultaneously (study the relationship between the variables)
Multivariate statistics	Analyses of multiple variables simultaneously (study the relationships of multiple dependent and independent variables)
Dependent variables (DV)	Variables thought to be influenced by other variables to behave in a certain way.
Independent variables (IV)	Variables that cause a reaction in the DV, or it may explain why the DV fluctuates. It is thus assumed that changes in the IV will usually precede any change in the DV.

Table 5.5 Domains of statistical techniques and variables (Babbie, 2004; Tabachnick and Fidell, 2007)

In operations management research, multivariate statistical techniques are recommended for analysing complex data (Flynn *et al.*, 1990). Forza (2002) and Scudder and Hill (1998) summarised several multivariate statistical techniques which are useful in empirical data analysis (Table 5.6).

Multivariate statistics techniques	Purpose
Multiple regression	Predict the changes in the Dependent Variables (DV) in response to changes in the several Independent Variables (IV).
Multiple discriminant analysis	To understand group differences and predict the likelihood that an entity (individual or object) will belong to a particular class or group based on several metric IVs.
Multivariate analysis of variance/covariance (MANOVA/MANCOVA)	To simultaneously explore the relationship between several IVs (usually categorical data) and two or more DVs.
Cluster analysis	To classify a sample of entities (individuals or objects) into a smaller number of mutually exclusive subgroups based on the similarities among the entities
Factor analysis	To analyse interrelationships amongst a large number of variables and to explain these variables in terms of their common underlying dimensions (factors).
Structural equation modelling	To simultaneously test the measurement model (which specifies one or more indicator to measure each variable) and the structural model (the model which relates causal inference between multiple IVs and DVs).

Table 5.6 Main multivariate statistics techniques (Forza, 2002, p186)

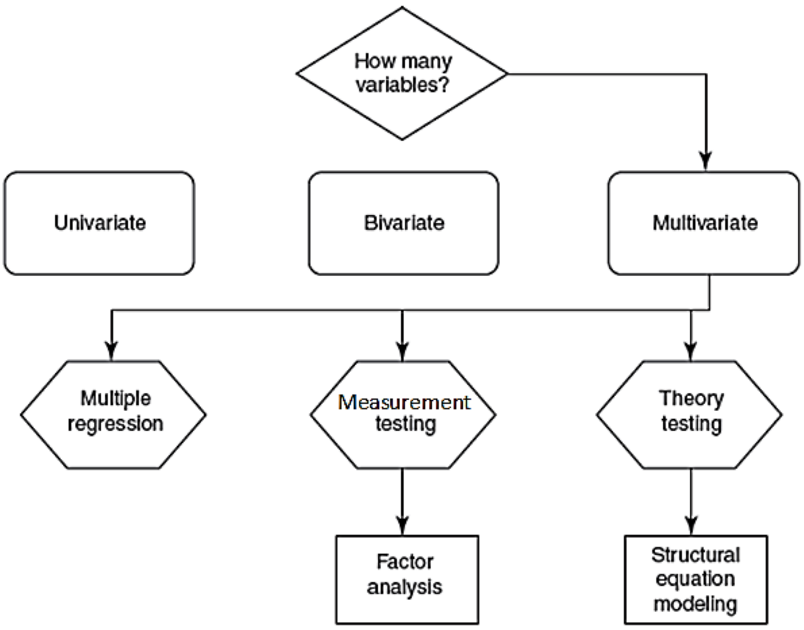


Figure 5.4 The choosing of the techniques based on Walker and Maddan (2012, p456)

According to the research questions and the collected data, this study follows Walker and Maddan (2012) to adopt factor analysis to identify underlying factors of the questionnaires measurement instruments and employs structural equation modelling to test the hypothesised causal relations (Figure 5.5).

5.1.5 A systematic approach of the research method

Based on the approaches proposed by Forza (2002), Oppenheim (1992), and Flynn et al. (1990), a systematic approach was used for guiding the research process and data collection (Figure 5.5).

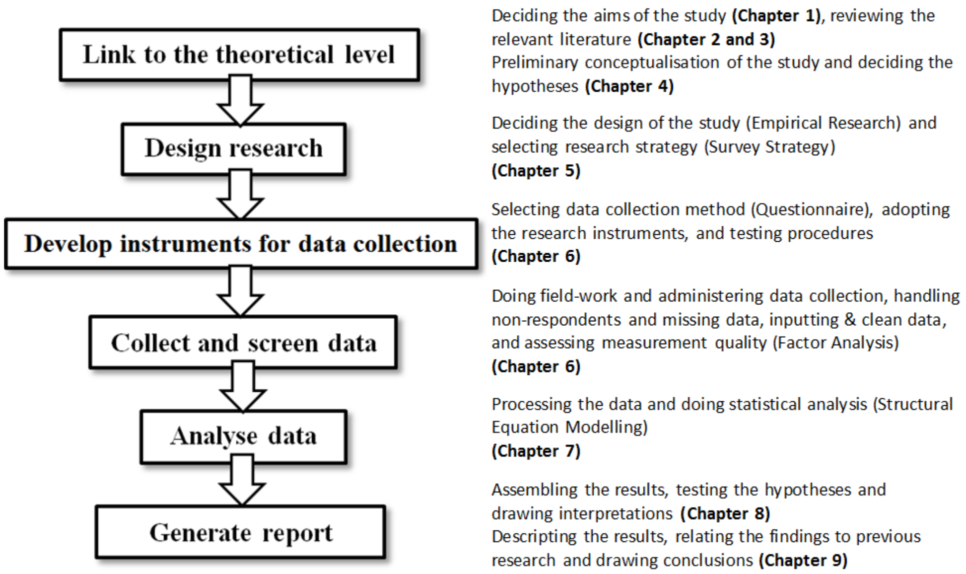


Figure 5.5 A systematic approach based on Forza (2002, p157), Oppenheim (1992, p7), and Flynn et al. (1990, p254)

<u>Link to the theoretical level</u>

In this step, the aims and objectives of the study were decided. They were presented in Chapter 1. The theoretical framework was established through a critical analysis of the literature where was detailed in Chapter 2 and 3. The development and articulation of the theoretical framework and research hypotheses were presented in Chapter 4.

<u>Design research</u>

This step justifies the research process design, strategy and data collection method. The reasons to select empirical deign and survey strategy were presented in Chapter 5 (this chapter, from Section 5.1.1-5.1.3).

Develop instruments for data collection

This step explains the adoption and development of the measurement instruments in the questionnaire. Because the constructs in operations management are complex and have multiple facets that cannot be generally measured directly (Forza, 2002), multi-items instruments are recommended for accurate and complete measurement (Hensley, 1999). This study followed the processes suggested by Oppenheim (1992), Malhotra and Grover (1998), Forza (2002), and Saunders et al. (2007) to develop the measurement instruments (Table 5.7). The details of these processes are illustrated in Chapter 6.

Define the questions (Wording)	Specify research domain based on existing literature to ensure content validity (the adequacy with which a measure or scale has sampled from intended domain of content). Formulate the questions with clear interpretations. They can be adopted, adapted or newly developed. Choose from open-ended (allowing respondents to answer in any way they choose) or closed (limiting respondents to a choice among alternatives given by the researcher) questions.
Decide the scales (Scalding)	Decide measurement scales to be used to measure the answers. The four basic types of scale are nominal (categorically discrete data, i.e., names), ordinal (quantities that have a natural ordering, i.e., Likert-scale), interval (similar to ordinal but each value are equally split, i.e., temperature), and ratio (similar to interval with a natural 0 point, i.e., fixed sum scale).
Identify the respondents (respondent identification)	Identify the population (the entire group of people, firms, plants or things that the researcher wishes to investigate), sampling frame (a listing of all the elements in the population), and the sample (a subset of the population, it comprises some members selected from the population) of the research. Select the appropriate informants to collect data. Probability sampling (or representative sampling) is the most commonly used method in survey strategy. It comprises four stages: identify a suitable sampling frame; decide a suitable sample size; select the sample; and check for the representative of the population.
Put together and test questions (Rules of questionnaire design)	Construct the questionnaire, including the layout, order and flow of the questions, and translate the questions into other languages (if needed). Pilot test the questionnaire.

Table 5.7 Processes to develop questionnaires (Flynn *et al.*, 1990; Oppenheim, 1992; Malhotra and Grover, 1998; Forza, 2002; Pallant, 2007; Saunders *et al.*, 2007; Karlsson, 2009)

Collect and screen data

This study followed the processes developed by Hair et al. (2010) and Tabachnick and Fidell (2007) to screen the data, obtain descriptive statistics and handle the non-response bias using SPSS (Table 5.8). The details of these processes are illustrated in Chapter 6. Factor analysis was adopted to manage the data, analyse the interrelationships amongst the variables (to discover the underlying factors) and evaluate these relationships (to ensure construct validity, the extent to which the factors were correctly correlated to measure the reality). The processes of performing factor analysis are described in Section 5.2. The results and measurement quality assessment are showed in Chapter 6.

Descriptive statistics for accuracy of inputs	Out-of-rang values Plausible means and standard deviations Missing data Outliers (univariate and multivariate)
Check for nonlinearity and homoscedasticity	Inspected by scatter plot and graphical plot of the variables
Identify nonnormal variables	Inspected by skewness and kurtosis of the variables
Evaluate construct validity (multicollinearity and singularity)	Inspected by Factor Analysis
Assess measurement reliability	Estimated by Cronbach's Alpha

Table 5.8 Processes to screen the collected data (Tabachnick and Fidell, 2007; Hair *et al.*, 2010)

<u>*Analyse data*</u>

This step analysed the collected data in order to test the hypothesised causal relationships between the application of shop floor management tools and the performance of *Kaizen*. Structural equation modelling was adopted to test the hypothesised causal relationships. This analytic tool is described in Section 5.3 and the results of the analyses are presented in Chapter 7.

<u>*Generate report*</u>

This step concluded the research. Chapter 8 assembled the results of the analyses to test the research hypotheses and explains the implications. Finally, Chapter 9 makes conclusions based on the findings, and identifies the limitations of the study for future research.

5.2 Factor Analysis

After the data are collected, the stability of the measurement instruments should be analysed and examined (Hensley, 1999). Factor analysis (Pearson, 1901; Spearman, 1904a; Thurstone, 1931) is a multivariate analysis procedure of data reduction (Bruin, 2006) which can be used to classify data and examine measurement instruments (Flynn *et al.*, 1990). The goals of a factor analysis are to: summarise the patterns within samples of collected data (Tabachnick and Fidell, 2007); identify their underlying relationships to create factors (or components) (Walker and Maddan, 2012); and test their relationships to ensure the construct validity (the extent to which the factors are correctly correlated for measurement) (Emory and Cooper, 1991; Lu, 2006).

5.2.1 The approaches and analysing assumptions for factor analyses

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) are the two types of factor analysis (Kline, 1994; Pallant, 2007). EFA has been described as an orderly simplification of interrelated measures (Suhr, 2006). It is generally used to explore and uncover the possible or proposed underlying structure of a large set of variables (Pedhazur and Schmelkin, 1991). CFA is a more rigorous statistical technique that is commonly used to test or verify a set of previous developed variables (Pedhazur and Schmelkin, 1991; Suhr, 2006), but it allows some minor modifications in terms of grouping (Walker and Maddan, 2012). Despite the differences between the two methods, a clear-cut distinction in their applications is not always recommended (e.g., Jöreskog, 1974; Anderson and Gerbing, 1988). It is therefore not practical to have a strict dichotomy of these two methods.

Factor Analysis assumes that data are normally distributed (Tabachnick and Fidell, 2007). However, if the data approximates interval level (i.e., Likert-scales data provided the scale item has at least 5 and preferably 7 categories), factor analysis can be used (Lehmann and Hulbert, 1972; Field, 2005; Walker and Maddan, 2012). In addition, a sufficient sample size is required (Pallant, 2007; Tabachnick and Fidell, 2007). Nevertheless, there is little consensus amongst researchers concerning a suitable sample size (Zhao, 2009). For instance, Hatcher (1994) recommended that the sample size should be at least 100. Tabachnick and Fidell (2007) indicated that a minimum of 300 cases is necessary. Field (2005) similarly asserted that 300 cases is probably adequate, but only if the communality values (the extent to which a variable correlates with all other variables) after factor extraction are above 0.5. A more rigorous requirement proposed by Nunnally and Bernstein (1994) recommends using at least 10 cases for each variable. In general, the larger the sample size the better (Bruin, 2006; Pallant, 2007).

5.2.2 The application of factor analysis

Factor analysis commonly comprises five steps (Pallant, 2007; Walker and Maddan, 2012) (Figure 5.6).

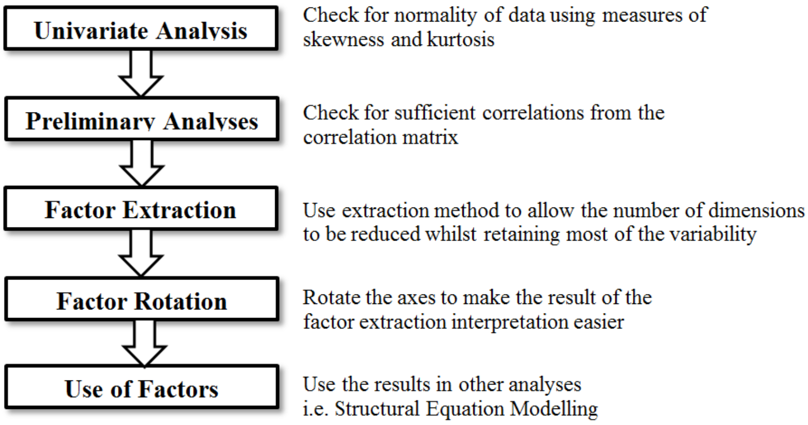


Figure 5.6 A five-step process for factor analysis (Walker and Maddan, 2012)

Univariate analysis

This important step checks for normality of data using measures of skewness and kurtosis (Walker and Maddan, 2012). If the data contains skewed or kurtoses variables, a 'bootstrap' method (a technique to maximise the accuracy of the estimation by creating multiple repeated samples from the original data set and examining each of the repeated samples) (Efron, 1979; Efron and Tibshirani, 1993) might be used to determine the bias (Ichikawa and Konishi, 1995; West *et al.*, 1995; Loehlin, 2004, p. p60).

Preliminary analyses

This step assesses the suitability of the data for factor analysis. It is recommended that the variables need to be intercorrelated, but high multicollinearity makes it difficult to determine the unique contribution to a factor (Field, 2005). Bartlett's Test of Sphericity tests whether there is sufficient intercorrelation between variables for factor analysis ($p<0.05$). The determinant of the correlation matrix checks for excessive correlation and should be greater than 0.00001 (Field, 2005; Pallant, 2007). The Kaiser-Meyer-Olkin (KMO) is another indicator of the strength of the relationship amongst variables (Kaiser, 1974). It is "a measure of sampling adequacy that compares the magnitudes of the calculated correlation coefficients to the magnitudes of the partial correlation coefficients" (Pett *et al.*, 2003, p77). The KMO value varies between 0 and 1, and values closer to 1 are better (Table 5.9) (Bruin, 2006). However, of 0.6 or greater (preferably 0.7 or above) shows sample adequacy for factor analysis (Field, 2005).

The KMO ranges between 0 and 1:
Above 0.90 is "marvellous"
In the 0.80s is "meritorious"
In the 0.70s is just "middling"
Less than 0.60 is "mediocre", "miserable" or "unacceptable"

Table 5.9 The KMO sampling adequacy, based on Kaiser (1974, p35) and Pett et al. (2003, p78)

Factor extraction

This step determines the most significant factors or dimensions that represent the interrelations among the set of variables (Pallant, 2007). It involves a method to reduce the number of dimensions whilst retaining most of the variance in the original data set (Johnson and Wichern, 2007). SPSS provides seven common extraction approaches (Table 5.10) to determine the factors (factor loading values will be printed in the Factor Matrix to indicate the correlations between variables and factors), possible values range from -1 to +1, and a higher value (positive or negative) indicates a closer correlation (Bruin, 2006; Walker and Maddan, 2012).

Extraction Technique	Goal of Analysis
Principal components	Maximise variance extracted by orthogonal components to convert correlated variables into principal components (Pearson, 1901; Hotelling, 1933).
Principal axis factoring (Canonical factor analysis)	Maximise covariance extracted by orthogonal factors to identify factors which have the highest canonical correlations with the observed variables (Rao, 1955)
Image factoring	Using multiple regression based on the correlation matrix of the predicted variables to provides an empirical factor analysis (Kaiser, 1963).
Maximum likelihood	Estimate factor loadings for population that maximise the likelihood of sampling the observed correlation matrix (Lawley and Maxwell, 1962)
Alphas factoring	Maximise the generalisability of orthogonal factors (Kaiser and Caffrey, 1965)
Unweighted least squares	Minimise squared residual correlations (Jöreskog, 1977)
Generalised least squares	Weights items by shared variance before minimising squared residual correlations (Browne, 1973).

Table 5.10 The comparisons of the factor extraction techniques in SPSS (Tabachnick and Fidell, 2007, p633)

Amongst those, Principal Components Analysis (PCA) (Hotelling, 1933) and Principal Axis Factoring (PAF, or Canonical Factor Analysis, developed by Rao, 1955) are two of the most popular approaches to extracting factors (Field, 2005; Walker and Maddan, 2012). In PCA, the original variables are transformed into a smaller set of linear combinations, using both variance and covariance (Tabachnick and Fidell, 2007; Walker and Maddan, 2012), to locate principle components based on their eigenvectors (principal direction) and eigenvalues (strength/length) (Smith, 2002; Stevens, 2002). With PAF, factors are estimated, using only the covariance (common variance), to identify underlying and unique common factors (Suhr, 2005; Pallant, 2007; Tabachnick and Fidell, 2007). Both PCA and PAF can yield very similar results (Stevens, 2002), especially if the correlation coefficients between the original variables are strong (Walford, 2009). However, PAF may be more suitable if some measurement error is present (Walford, 2009; Henriques, 2011). PCA is the better choice for a simple empirical summary of the data set (Tabachnick and Fidell, 2007).

After the extraction, it is necessary to determine the numbers of factors that should be retained. Three common techniques can be used to assist in the decision: (1) Kaiser's criterion (Kaiser, 1960), in which only factors with an eigenvalue of 1 or above are retained. The eigenvalue of a factor represents the average amount of the variance explained by that factor, so a factor with an eigenvalue of 1 makes an average contribution to the overall variance; (2) Cattell's screen plot (Cattell, 1966) uses a graphical representation to indicate the incremental variance of the eigenvalues of the factors. Cattell (1966) suggested retaining all factors where the screen plot becomes horizontal or levels off (e.g., Figure 5.7); (3) Horn's Parallel analysis (Horn, 1965) uses a simulation method (e.g., Monte Carlo Method by Metropolis and Ulam, 1949) to compare the size of the observed eigenvalues with those obtained from a randomly generated data set of the same size (Pallant, 2007; Walker and Maddan, 2012). Only the factors with associated eigenvalues that exceed the corresponding eigenvalues derived from the random data set are retained (Pallant, 2007). This is a statistical sampling technique (Eckhardt, 1987) that can correct the bias in the Kaiser's criterion by using a 'sufficiently large' sample (Dino, 2009).

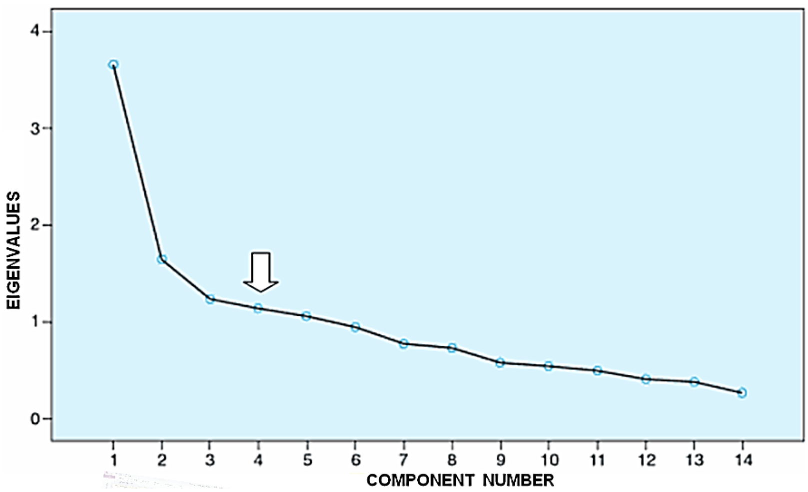
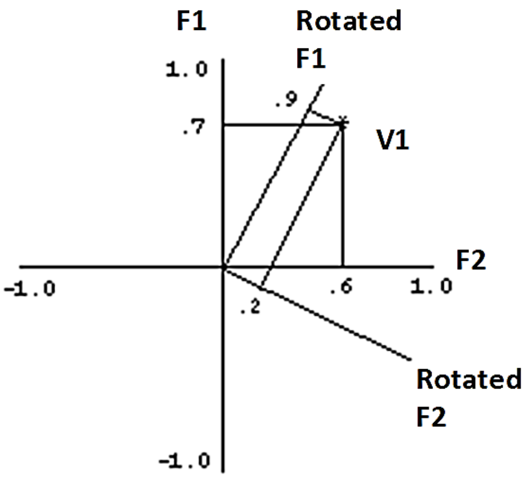


Figure 5.7 Screen plot (Walker and Maddan, 2012, p466)

Factor rotation

Once the number of factors to extract is determined, factor rotation may be performed to facilitate a clear understanding and interpretation of the data (Walker and Maddan, 2012). It rotates the reference axes (coordinate plane) of the original factor solution to simplify the factor structure (i.e., placing all of the factors in the same quadrant) (e.g., Figure 5.8), so the geometric location of the factors becomes more meaningful and makes an interpretable solution (from the original Factor Matrix to the rotated Pattern Matrix).



The variable V1 initially has factor loadings of 0.7 and 0.6 on F1 and F2 respectively. However, after rotation the factor loadings have changed to 0.9 and 0.2 on the Rotated F1 and F2 respectively, which is closer to a simple structure and easier to interpret.

Figure 5.8 An example of factor rotation (ucla: Statistical Consulting Group., 2007)

SPSS provides two main approaches to rotate the factors. They are orthogonal (uncorrelated) and oblique (correlated) approaches (Abdi, 2004; Field, 2005; Walker and Maddan, 2012). Orthogonal rotation (Kaiser, 1958) (i.e., *varimax*, *quartermax* and *equamax*) results in solutions where the reference axes are uncorrelated and the angle between the reference axes of factors are maintained at 90 degrees (ucla: Statistical Consulting Group., 2007; Walker and Maddan, 2012). With oblique rotation (Carroll, 1953) (i.e., direct *oblimin* and *promax*) the axes are correlated and the angle between the reference axes are not at right angles (Field, 2005; Pallant, 2007; Walker and Maddan, 2012). Both approaches often result in very similar results, especially when the pattern of correlations amongst the items is clear (Tabachnick and Fidell, 2007). However, orthogonal rotations should be used if the factors are uncorrelated, and oblique rotations may be adopted if the factors are correlated (ucla: Statistical Consulting Group., 2007).

Use of factors in other analyses

The final step is 'Use of Factors', in which the results of factor analysis can be used in other analyses, such as structural equations modelling (Walker and Maddan, 2012).

5.3 Structural Equation Modelling

Structural equation modelling (SEM) is a second-generation (Chin, 1998) multivariate statistical analytical tool (Suhr, 2012) that is used to identify and depict relationships amongst variables (Kline, 2005). SEM can be defined as "a hypothesis of a specific pattern of relations among a set of measured variables and latent variables" (Shah and Goldstein, 2006, p166).

5.3.1 An overview structural equation modelling and path analysis

SEM includes a family of statistical methods (i.e., multiple regression, variances and covariance) (Valluzzi *et al.*, 2003) to simultaneously test the causal processes represented by a series of regression equations (Byrne, 2010). It has been used widely for complex hypothesis testing (Grace, 2012) and confirmatory study (Wu, 2009). In addition, SEM is a form of graphical modelling that aims to provide an effective quantitative test (Kline, 2005). Therefore, in SEM, the causal processes can be modelled pictorially to create a clearer theoretical framework. The following Figure 5.9 shows the graphical symbols.

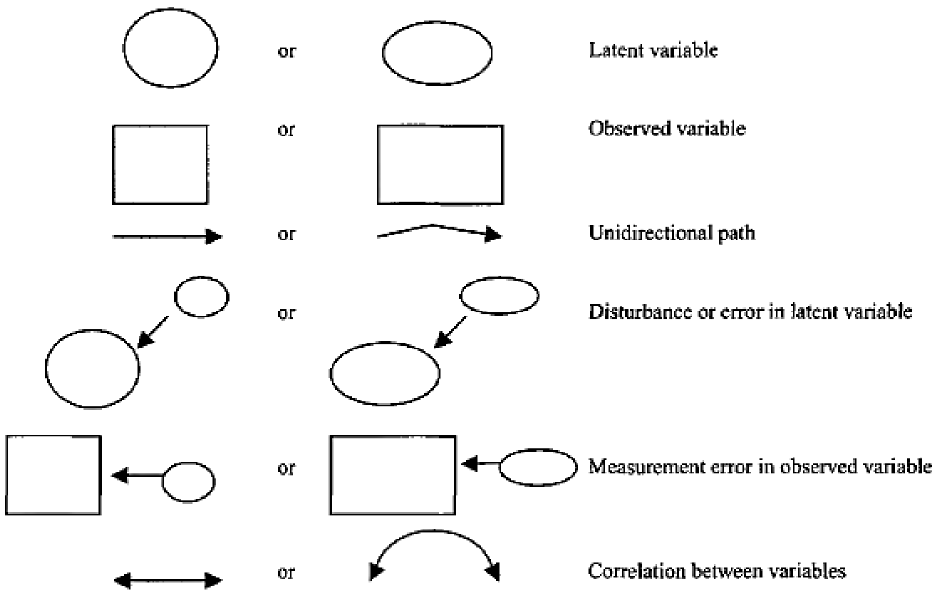


Figure 5.9 SEM diagram symbols, adopted from Schumacker and Lomax (2004, p153)

SEM includes two types of variables (McDonald and Ho, 2002): *observed variables* and *latent variables* (Bentler and Weeks, 1980; Kline, 2005). The *observed (measured) variables* are variables that can be directly observed or measured (Streiner, 2006). The *latent variables* are not directly observable; SEM additionally represents the *measurement error* associated with each observed variable (Byrne, 2010). Latent variables are inferred constructs based on the observed variables. Accordingly, SEM uses correlation coefficients and regression analysis to establish causal relationships among observed/latent variables (Ullman, 2007). It uses causal arrows to express the causes and effects between exogenous (independent or source) variables and endogenous (dependent or downstream) variables based upon some underlying theory (Loehlin, 2004; Byrne, 2010).

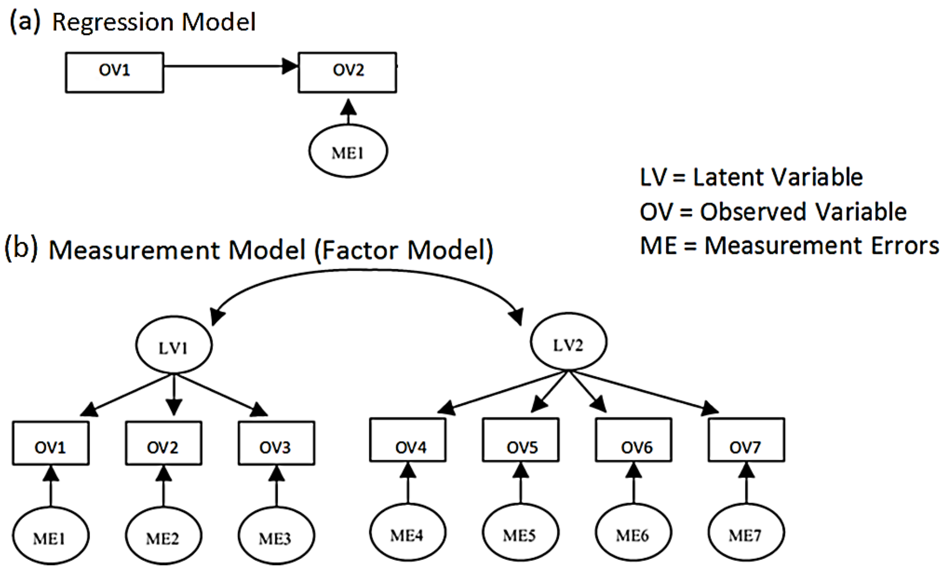


Figure 5.10 Illusions of Regression Model and Factor Model based on Shah and Goldstein (2006, p150)

SEM tests three types of basic models (Schumacker and Lomax, 2004): (1) Regression Models (Figure 5.10 (a)) to test hypothesised causal relationships between latent variables (Pearson, 1936); (2) Factor Models (Figure 5.10 (b)) to test relationships amongst observed and latent variables (Spearman, 1904b; Spearman, 1927); and (3) Path Models (Figure 5.11) to structure complex causal relationship amongst observed/latent variables as well as between latent variables (Wright, 1918; Wright, 1921; Wright, 1934; Wright, 1960).

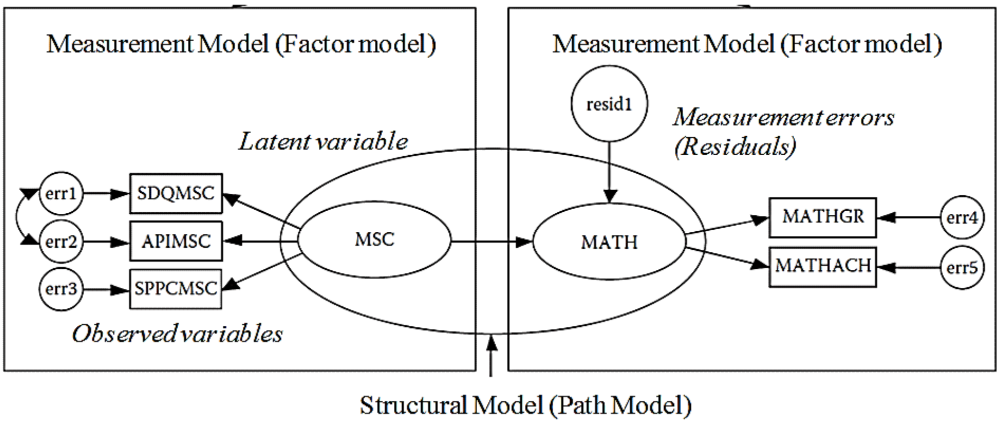


Figure 5.11 A general structural equation model demarcated into measurement (Byrne, 2010, p13)

The Path Model (Path analysis or PA) is a useful multivariate technique that combines aspects of factor analysis (Hoyle, 1995) and multiple regression analysis (Cunningham and Wang, 2005) to provide appropriate estimations for a series of separate multiple regression equations simultaneously (Hair *et al.*, 2010).

5.3.2 The widespread of structural equation modelling

SEM has been widely used for PA to study causal relationships (Mitchell, 1992; Jöreskog and Sörbom, 2001; Loehlin, 2004). In fact, the use of a graphical method for modelling multivariate relations in PA is only one of SEM's major advantages (Kline, 2005; Yuan *et al.*, 2010; Oke *et al.*, 2012). Additionally, there are at least five other advantages of using SEM for modelling multivariate relations: *first*, it has the capability to assist with the theory verification by effectively dealing with a large number of variables and complex phenomena (Ullman, 2007); *second*, it is useful in survey research and hypothesis testing studies (Oke *et al.*, 2012); *third*, the calculations of path effects (Anderson and Gerbing, 1988) and measurement errors in SEM are computed simultaneously (Kline, 2005) which differ from the calculations in the traditional statistical programmes (e.g., SPSS or SAS), where the latter calculations are estimated separately (Schumacker and Lomax, 2004); *fourth*, it has the capability to provide high validity and reliability model estimates by assessing or even correcting the measurement errors (Byrne, 2010); and *fifth*, SEM dedicated programmes are readily available and have become increasingly user-friendly (Byrne, 2010). These advantages have set SEM apart from other basic statistical methods for modelling multivariate relations. As Byrne (2010, p4) indicates, "there are no widely and easily applied alternative methods for modelling multivariate relations, or for estimating point and/or interval indirect effects; these important features are available using SEM methodology".

Therefore, SEM has become one of "the preeminent multivariate technique(s)" (Hershberger, 2003, p35) and been "applied to a diverse array of topics" (Loehlin, 2004, p116), "across all disciplines" (Schumacker and Lomax, 2004, p6), such as for the research in pedagogy, marketing (Hair *et al.*, 2011), economics, criminology, demography (Li, 2004), public health, business management, sociology, psychology (Byrne, 2010), medicine, political science and biological science (Schumacker and Lomax, 2004). Likewise, SEM has also become one of the favoured data analysis methods for conducting empirical research in business and management (e.g., Table 5.11) (Hult *et al.*, 2006), including strategic management (e.g., Calantone and Zhao, 2001; Shook *et al.*, 2004), logistics (e.g., Garver and Mentzer, 1999), supplier relationships (e.g., Cousins and Lawson, 2007), quality management (e.g., Lin *et al.*, 2005), organisational research (e.g., Medsker *et al.*, 1994) and operations management (e.g., Shah and Goldstein, 2006), In particular, SEM has been ranked one of the top analysis methods in the *Journal of Production and Operations Management* during the period 1992 to 2005 (Gupta *et al.*, 2006).

Literature	Focus
(Chong *et al.*, 2001; Anderson-Connolly *et al.*, 2002; Fullerton and Wempe, 2005; Politis, 2005; Hoang *et al.*, 2006; Cousins and Lawson, 2007; Dal Pont *et al.*, 2008; Verworn *et al.*, 2008; Wang and Cao, 2008; Fotopoulos and Psomas, 2009; Fullerton and Wempe, 2009; So and Sun, 2011; Agus and Hajinoor, 2012; AL-Tahat and Alkhalil, 2012; Bahri *et al.*, 2012; Chettiar *et al.*, 2012; Fullerton *et al.*, 2012; Habidin *et al.*, 2012; Hong and Rawski, 2012; Zubir and Habidin, 2012)	The relationships between Lean related practices, shop floor management, and organisational/financial performance
(Kanji, 1998; Ahire and Dreyfus, 2000; Prajogo and Sohal, 2006; Maranto-Vargas and Gómez-Tagle Rangel, 2007; Chen *et al.*, 2008; Dahlgaard-Park, 2009; Ni and Sun, 2009; Tian *et al.*, 2010; Aloini *et al.*, 2011; López and Morales, 2011; Peng *et al.*, 2011; Yang *et al.*, 2011; AL-Tahat and Bataineh, 2012; Hashim *et al.*, 2012; Oke and Kach, 2012; Zeng *et al.*, 2013)	The relations between continuous improvement practices and organisation performance/business performance
(Hallgren and Olhager, 2009; Daniel *et al.*, 2010; Nagati and Rebolledo, 2012; Vinodh and Joy, 2012; Zhou *et al.*, 2012)	The critical success factors and Lean production implementation
(Corsten and Felde, 2005; Fynes *et al.*, 2005; Li *et al.*, 2006; Agbejule and Burrowes, 2007; Cousins and Lawson, 2007; Koh *et al.*, 2007; Lawson *et al.*, 2009; Agus, 2011a; Agus, 2011b; Shamah, 2013a; Shamah, 2013b; Sukwadi *et al.*, 2013; Zeng *et al.*, 2013)	The relationships between supply chain management, quality management, and improvement performance
(Rao, 2004; Rao and Holt, 2005; Shazali *et al.*, 2013)	Lean production in other sector and performance

Table 5.11 Selected business and management literature on structural equation modelling

5.3.3 The application of AMOS in developing and analysing SEM

Many programmes, such as LISREL (SSI, 2012), CALIS in SAS/STAT (Yung, 2010), EQS (Bentler and Wu, 2012), AMOS (Arbuckle, 2007), Mplus (Mplus Development Team, 2013) and others, can be used to perform SEM (Hox, 1995; McDonald and Ho, 2002; Kline, 2005). In fact, the choice of the programme for SEM is often based on personal perference (Worthke, 2013). In this thesis, AMOS was used for the data analysis. AMOS (Analysis of Moment Structures) is a package within the IBM SPSS family (Arbuckle, 2007). It has a rich and visual framework that allows users to easily compare, confirm and refine models (IBM, 2011). Schumacher and Lomax (2004) introduced a five-step process for developing and analysing structural equation models (Figure 5.12).

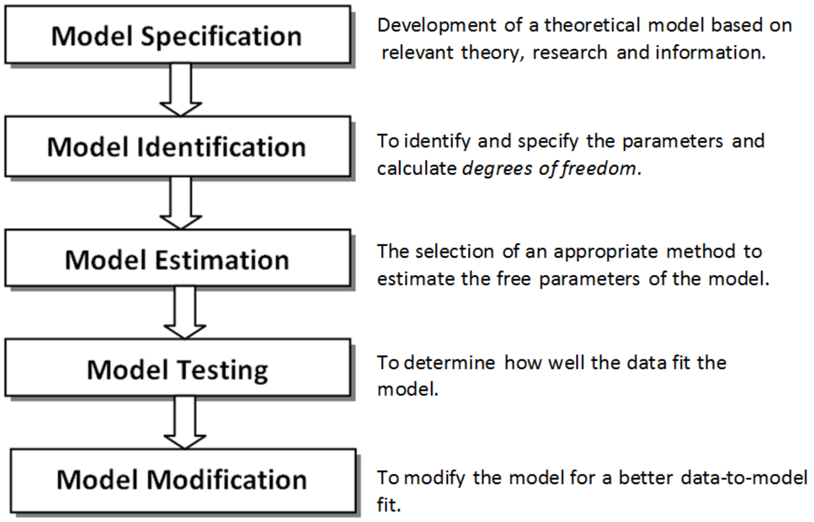


Figure 5.12 A five-step process in developing and analysing SEM (Schumacker and Lomax, 2004)

<u>*Model specification*</u>

It involves the development of a theoretical model based on all of the available relevant theory, research, and information. SEM is an '*a priori*' technique in which the theory drives the development of the model (Valluzzi *et al.*, 2003). This is opposed to mining the data to develop a model (Kline, 2005). Thus, a theoretical model which involves determining relationships (paths) and/or parameters (variables) could be first specified and developed based on the findings from the literature review and theories before any data collection.

Model identification

This step is to identify and specify the parameters and calculate the *degrees of freedom* (*D.f*) prior to the estimation of the particular model. The *D.f.* of a model is defined as "the difference between the number of observations (or *distinct sample moments* in AMOS, calculated as m × (m + 1) ⁄ 2) and the number of its (free or estimated) parameters" (Kline, 2005, p100; Byrne, 2010). The following is the formula to calculate the D.*f.* of a SEM path model (Rigdon, 1994, p276):

$$\boldsymbol{D.f.} = m \times (m + 1) / 2 - 2 \times m - \xi \times (\xi - 1) / 2 - g - b$$

m: observed variables
ξ: latent variables (constructs/factors)
g: direct paths of exogenous constructs on endogenous constructs
b: direct paths of endogenous constructs on each other

A SEM model needs to be either just- or over-identified (*D.f.* ≥ 0) to generate accurate parameter estimates. Hence, an under-identified (*D.f.* < 0) SEM model cannot obtain unique estimates of the parameters (Table 5.12). Adding additional constraints (i.e., additional observed variables or constraint variables) or removing the number of constructs/factors could increase the degrees of freedom to change an under-identified model to be a just- or over-identified model. AMOS provides information about model identification in its output (Arbuckle, 2007).

Overidentified (*D.f.* > 0)	SEM model that has more number of observations than free parameters to be estimated. It has positive degrees of freedom.
Just-identified (*D.f.* = 0)	SEM model containing just enough degrees of freedom to estimate all free parameters.
Underidentified (*D.f.* < 0)	SEM model with more parameters to be estimated than there are observations. It has negative degrees of freedom.

Table 5.12 The three levels of model identifications by Hair et al (2010) and Schumacker and Lomax (2004)

Once the model has been identified, the statistical power (π) of a model needs to be examined to establish the probability of errors. In statistics, there are two types of probability errors: Type I error and Type II error (Table 5.13). Type I error refers to the failure to accept a true null hypothesis (or H_0, a default hypothesis, i.e., there is no relationship between two measured phenomena), whereas a Type II error refers to the failure to reject a false null hypothesis (H_0) (Neyman and Pearson, 1933).

Decision	True population	
	H_0 is true	**H_0 is false**
Reject H_0	Wrong decision, Type I error	Correct decision
Fail to reject H_0	Correction decision	Wrong decision, Type II error

Table 5.13 The two types of probability errors (Walker and Maddan, 2012, p330)

The statistical power (π) is to calculate the probability of correctly rejecting a false hypothesis (Cohen, 1988). The following formula can be used for the calculation in a SEM model:

$$\textbf{Statistical power } (\pi) = 1 - \beta$$

β: the probability of a Type II error

In addition, both of the sample size and the *degrees of freedom* affects the statistical power of the model estimations (McQuitty, 2004). In order to achieve a desired level of statistical power for a reliable model, it is necessary to determine the required sample size with associated degrees of freedoms of the model (Hoe, 2008). Hence, the minimum required sample size should be considered when forming the SEM to estimate measures or develop theory (Table 5.14).

D.f.	π = 0.60, N≥	π = 0.70, N≥	π = 0.80, N≥	π = 0.90, N≥
5	885	1132	1643	1994
20	280	346	435	572
50	145	175	214	274
100	92	110	132	165
150	72	85	101	125
200	61	71	84	104
400	41	48	56	68

Table 5.14 Minimum sample size required to achieve specified statistical power (McQuitty, 2004, p181)

Model estimation

This step involves the selection of an appropriate fitting procedure to estimate the free parameters of the model. In SEM, many procedures, such as maximum likelihood, LISREL's initial estimates (Jöreskog and Sörbom, 2001), EQS's distribution-specific and distribution-free estimates (Bentler, 1988), and many others (see Hair *et al.*, 2010, p638) can be used for parameter estimations. Each of these procedures estimates a best-fitting solution and evaluates the model fit according to the size, distributional assumptions and scale dependency (changes in observed variable scale yield different solutions or sets of estimates) of the data samples (Wu, 2009). AMOS provides five SEM procedures (Table 5.15) for parameters estimations: Maximum likelihood (ML), Generalised least squares (GLS), Unweighted-least squares (ULS), Scale-free least squares (e.g., Weighted-least squares or WLS) and Asymptotic-distribution free (ADF) (Anderson and Gerbing, 1988; Barndorff-Nielsen and Cox, 1989; Schumacker and Lomax, 2004, p66).

Estimation procedures	Normality assumption	Sample size	Scale Dependent
Maximum likelihood (ML)	Yes	the more the better	No
Generalised least squares (GLS)	Yes	the more the better	No
Unweighted-least squares (ULS)	No	more than 1000	Yes
Scale-free least squares (WLS)	No	more than 1000	No
Asymptotic-distribution free (ADF)	No	more than 1000	No

Table 5.15 The SEM estimation procedures in AMOS, adopted from Byrne (2010) and Wu (2009)

Amongst these five procedures, the ULS, WLS and ADF have no distributional assumptions or associated statistical tests; hence the multivariate normality of the data is not required (Rong, 2009). However, they have desirable asymptotic (large sample) properties, that is, the requirements of the random sample size must be over 1000 (Wu, 2009). In addition, the ULS method is a scale dependent method. Accordingly, the changes in observed variable scale yield different estimates (Schumacker and Lomax, 2004).

In comparison, the ML and GLS are more robust methods in many cases (McDonald and Ho, 2002). They are scale free (Schumacker and Lomax, 2004) and they have lower sample size requirements, although the more the better, as the size decreases, non-normality increases (Jöreskog and Sörbom, 2001; Byrne, 2010) and the statistical power reduces (Saris and Satorra, 1993; McQuitty, 2004; Fadlelmula, 2011). These two methods can generate very similar results (Muthen, 1973; Wu, 2009, p. 25), especially when the model is correctly specified (Olsson *et al.*, 2000), and they have similar implementation requirements (Olsson *et al.*, 2000; Byrne, 2010). Both of these methods require the data to be continuous, with minimum variance, unbiased, and multivariate normal (Schumacker and Lomax, 2004; Byrne, 2010). The violation of these assumptions could significantly affect the estimated results (Kline, 2005). The GLS could be preferable to the ML if the assumptions are not too seriously violated (Wu, 2009), as it could produce a better empirical fit (Browne, 1973; Ding *et al.*, 1995). However, Olsson et al. (2000) showed that this superiority is compromised at the cost of lower theoretical fit (supported by the theory). Olsson et al. (2000, p560) explained that "parameter estimates for correctly specified paths within a partly misspecified model [not fully supported by the theory] were found to be significantly more biased for GLS than for ML."

Model testing

This step is to determine how well the data fits the proposed model or to what extent the theoretical model is supported by the collected sample of data. Some common testing indices can be used to indicate the model fit: the parameter estimates with statistical significance level and standard errors, the residuals, and the model fit indices.

Generally, the first process in assessing the fit of the individual parameters in a model is to determine the viability of their estimated values, statistical significance level, and their accompanied standard errors (S.E.) (Jöreskog and Sörbom, 2001; Bentler, 2005). According to Hoyle (1995), the critical ratio (C.R. or Z score, calculated by the parameter estimate / S.E. of the parameter estimate) is significant at $p<0.05$ level if its value exceeds ±1.96 (providing the data is normally distributed, rejecting H_0 or null hypothesis, but 5% of the time a Type I error would be committed). The parameters estimates with $p>0.05$ are considered insignificant or unimportant paths to the model (accept H0, but still 5% of the time a Type II error would be committed) (Wu, 2009; Walker and Maddan, 2012). In addition, the estimated values should exhibit the correct sign, within an expected range, and be consistent with the underlying theory (Schumacker and Lomax, 2004; Byrne, 2010).

Next, an examination of the Standardised Residual Covariance Matrix (from AMOS output to review the discrepancy between each of the residual) could also give evidence of the model fit to the hypothesised model (Wu, 2009). On the recommendation of Rong (2009) and Jöreskog (1993), standardised residuals (fitting errors) within the range of ±2.58 indicates a good model fit, and accordingly, when the residuals fall outside this range it indicates that the associated estimated values (i.e., path relations) are not well accounted for by the model. They reflect the misspecifications of relationships between different parameters (paths/variables) in the model (Schumacker and Lomax, 2004).

Furthermore, the model fit indices need to be assessed (Anderson and Gerbing, 1988; Cousins and Lawson, 2007). If the indices show the model fit is good, the sample data should fit the hypothesised path model (Wu, 2009; Byrne, 2010). AMOS provides the following common fit indices to indicate the specified data to model fit (Table 5.16).

Model Fitness Statistics	Fitness Indices
Normed indices of fit	
Chi-square (χ^2)	$p > .05$
Goodness-of-Fit (GFI)	> 0.9
Adjusted Goodness-of-Fit (AGFI)	> 0.9
Root-Mean-Square Residual (RMR)	< 0.05
Standardised RMR (SRMR)	≤ 0.05
RMR of approximation (RMSEA)	≤ 0.05
Expected Cross-Validation Index (ECVI)	< saturated and independence model
Incremental indices of fit	
Normed Fit Index (NFI)	> 0.9
Relative Fit Index (RFI)	> 0.9
Incremental Fit Index (IFI)	> 0.9
Tucker-Lewis Index (TLI)	> 0.9
Comparative Fit Index(CFI)	> 0.9
Parsimony-based indices of fit	
Parsimony-Adjusted CFI (PCFI)	> 0.5
Parsimony-Adjusted NFI (PNFI)	> 0.5
Critical N (CN)	> 200
Normed Chi-Square (NC, CMIN/DF)	1 < NC < 3

Table 5.16 The common model fitness indices in AMOS (Schumacker and Lomax, 2004, p87; Wu, 2009; Byrne, 2010)

Model modification

A model modification is applied to the initial hypothesised SEM model to seek a better fitting for the sample data. According to Chou and Bentler (1990) and MacCallum et al. (1992), model modification could generate more than one model (sometimes it could end up with a large number of models) that fit a data set well. As such, a theory-driven (vs. data-driven) model modification should be performed. The model modification consists of the following three common processes: (1) remove the insignificant parameters (paths) to form a better fitting model (Byrne, 2010); (2) remove the variables which have standardised residual values that fall outside ±2.58 (Wu, 2009); and (3) include new parameters (paths) if they reach the significant level ($p<0.05$) and are supported by the underlying theories (Schumacker and Lomax, 2004).

After the modification, the modified model should have increased model fit indices which would indicate that the data-to-model fit is at a satisfactory level. Thus, the modified model can be deemed as the final path model for the theoretical model and it also can be used to test the research hypotheses.

5.3 Summary

This chapter discussed the methodology that has been used in this research. It explains the reasons for choosing the research strategy (survey), data collection method (questionnaire), and analysis method (factor analysis and structural equation modelling) of the current research. It also introduced the use of SEM in the previous research and explained a five-step process to use AMOS for developing and analysing structural equation models. The next chapter covers the adoption of the questionnaire, data collection, and the validation of the measures.

Chapter 6 Data Collection

This chapter describes the data collection and screening procedures. It is divided into 4 sections: section 6.1 details the development of the constructs in the questionnaire and the procedures for data collection. Section 6.2 presents demographic features of the respondents. Section 6.3 and 6.4 explain the procedures for measuring the validity and reliability of the factor constructs from the collected data set.

6.1The Questionnaire and Data Collection

The questionnaire used in this study contained three sections and 45 questions (

Appendix C). The questions were derived from three previous studies. In particular, they comprised 16 questions based on Bateman (2000) to measure the implementation of the four building block shop floor management tools; 12 questions based on Lillrank and Kano (1989) to evaluate the implementation of QCCs and *Teians*; and 17 questions which were developed by Doolen et al. (2003) to measure the improvement outcomes.

6.1.1 The constructs of the questionnaire and research domains

A questionnaire construct is an attribute or characteristic inferred from research (Hayes, 2008). In respect to the research objectives, the constructs (or scales) in the questionnaire of this study were derived from the literature relating to: Lean Production shop floor management, continuous improvement and improvement outcomes (as described in Chapter 2 and 3).

According to Forza (2002) and Hensley (1999), the constructs in operations management are complex and have multiple facets, hence, multi-items constructs were used. In addition, suggestions made by Oppenheim (1992) and Flynn (1990) were followed to use the existing pre-tested constructs from past empirical studies for two particular reasons: (1) to ensure their content validity; and (2) the objective of this study was to test the causal relationships between the application of shop floor management tools and the performance of *Kaizen*. Therefore, the complexity of the construct development process and validation was reduced to a minimum (Prajogo, 2002). The development of the constructs included in the hypothesised model was based on the three domains described in Figure 6.1.

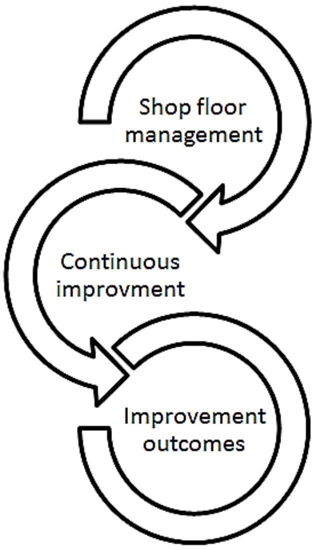


Figure 6.1 Domains of literature used as sources for questionnaire constructs

6.1.2 Structure of questionnaire

The questionnaire used in this study contained four sections and 45 questions (Appendix C). The first section contained the objectives of the questionnaire, assurance of confidentiality of the responses, brief instructions on how to complete the questionnaire and information regarding respondent's profile, including education qualifications, job title in the organisation, years working in the organisation, years of participation in improvement activities and group improvement position. The second part contained constructs based on Lillrank and Kano (1989) to evaluate the implementation of QCCs and *Teians.* The third section comprised constructs based on Bateman (2000) to measure the implementation of the four building block shop floor management tools and section four was derived from Doolen et al. (2003) to measure the improvement outcomes.

6.1.3 Questionnaire scaling

Operations management research covers many issues and concepts that are not directly observable (Hensley, 1999; Karlsson, 2009). In order to capture, measure, and translate these issues and concepts in a more systematic and formalised way (Miller and Salkind, 2002; Corbetta, 2003), the technique of scaling is commonly used (Flynn *et al.*, 1990; Saunders *et al.*, 2007). According to Corbetta (2003, p164-165), scaling is "a set of procedures drawn up by social research to measure human beings and society"; in particular, each scale consists of a set of items, and each item measures a single component (i.e., statement, question, behaviour, test, response, attribute).

In operations management research, Flynn el al. (1990), based on Alreck and Settle (1985), provided a brief description of some potentially useful scales. Amongst those, the Likert-scale (1932) is the most frequently used (Aday and Cornelius, 2006; Saunders *et al.*, 2007) and highly reliable measuring tool (Corbetta, 2003; McNabb, 2008). It was put forward by Likert in 1932 and met with considerable success (and still is today) (Corbetta, 2003). The Likert-scale can be used to measure the highly complex nature of the subject, as it uses simple evaluations/judgements to capture responses and the intensity of opinion (Albaum, 1997).

The current study adopted the Likert-scale to measure respondents' attitudes relating to continuous improvement. Following Krosnick and Fabrigar (1997, p143), the study used "bipolar scales" (scales reflecting two opposing alternatives with a clear conceptual midpoint) to measure respondents' attitudes on improvement outcomes and "unipolar scales" (scales reflecting varying levels of some construct with no conceptual midpoint and with a zero point at one end) to measure respondents' degree and utilisation of shop floor management tools. The original Likert-scale offered five-point categories/alternatives ("strongly approve", "approve", "undecided", "disapprove" and "strongly disapprove") (Likert, 1932), but the numbers of categories/alternatives were later changed (Corbetta, 2003). This study used a seven-point rather than a five-point Likert-scale to produce interval or interval-like data for later parametric statistics (i.e. factor analysis and structure equation modelling).

6.1.4 Operationalised measures for improvement implementation

This section describes the indicators used to measure implementation of continuous improvement. Some previous studies (Schuring and Luijten, 2001; Muthiah and Huang, 2007; Gupta and Boyd, 2008) have introduced the use of one-off performance indicators (e.g., throughput, inventory and operations expenses) to measure the results of improvement (Imai, 1986; Imai, 1997), but they fail to capture the important features of continuous improvement, the process (Marin-Garcia *et al.*, 2008).

This research measured the success of the continuous improvement based on employees' ways of doing things, such as the number of ideas they submitted (e.g., Karlsson and Ahlstrom, 1996), implemented (e.g., Winfield, 1994; Baides and Moyano–Fuentes, 2012), as well as the time they spent in developing ideas (e.g., Prado, 2001; Marin-

Garcia *et al.*, 2008). These indicators have been widely used to measure the process of continuous improvement (e.g., Santos and Powell, 2001; Seyedhosseini *et al.*, 2011; Miina, 2012). According to Lillrank and Kano (1989), the number of QCC meetings is a proxy to measure the *quantity of QCCs*, whilst the number of completed and presented QCCs is a proxy for *quality of QCCs*. The following questions were adopted to measure the implementation of QCCs (Table 6.1).

Constructs	Questions and measuring method
Quantity (QCCs)	This was measured by the total time spent on QCC meetings in a month, calculated by the product of the length of each meeting and the frequency of meeting on a monthly basis. • **QC_Meet_Times** In general, how many times do you meet every month for QCC? • **QC_Met_Length** In general, how long does each QCC meeting last?
Quality (QCCs)	This was measured by the numbers of completed QCC themes and the presentation made on the themes at company level. • **QC_Comp** How many QCC themes did your group complete last year? • **QC_Pres** How many times did you present in the meetings?

Table 6.1 The questions developed to measure the QCCs

The implementation of *Teians* was measured in the same way (Table 6.2). Following some previous studies (Cusumano and Takeishi, 1991; Coleman, 1993a; Coleman, 1993b; Nihon HR Kyōkai, 1995; Jha *et al.*, 1996; Terziovski and Sohal, 2000; e.g., Rapp and Eklund, 2002), the number of *Teians* submitted is a proxy to measure the *quantity of Teians* whilst the number of acceptances is a proxy to measure the *quality of Teians*.

Constructs	Questions and measuring method
Quantity (*Teians*)	This was measured by the number of submitted *Teians*. • **Tn_Sub** How many *Teians* did you submit in the last 12 months?
Quality (*Teians*)	This was measured by the number of accepted *Teians*. • **Tn_Acc** How many of these *Teians* were accepted for implementation?

Table 6.2 The questions developed to measure the *Teians*

6.1.5 Operationalised measures for the use of the shop floor management tools

This section contains 4 scales (16 questions) to measure the degree of adoption and utilisation of the four building block shop floor management tools following CINET (2002), Soriano-Meier (2002), Rahman (2001) Terziovski and Sohal (2000). The four shop floor management tools were selected based on Bateman (2001), and Bateman and Rich (2003). The respondents were asked to evaluate the frequency of their use of these tools using seven-point Likert-scales, ranging from 1 (**Never**) to 7 (**Always**), and the sum of the answers was used as an indicator to reveal the utilisation of each building block tools (a higher score indicates greater utilisation of the tool) (Table 6.3).

Scales	Questions and measuring method 1(Never) – 7(Always)
Implementation of 5S practice	• **I5S1** *Seiri* (Organisation) • **I5S2** *Seiton* (Neatness) • **I5S3** *Seiso* (Cleaning) • **I5S4** *Seiketsu* (Standardisation) • **I5S5** *Shitsuke* (Self-discipline)
Use of the standard operations	• **SDO1** Quality control sheet • **SDO2** Production standard sheet • **SDO3** Work standard sheet • **SDO4** Work procedure sheet
Implementation of waste removal	• **WSR1** Waste identification • **WSR2** Waste elimination • **WSR3** Waste prevention
Use of visual management	• **VSI1** Visual indicator • **VSI2** Visual signal • **VSI3** Visual control • **VSI4** Guarantee

Table 6.3 The questions developed to measure shop floor management tools

6.1.6 Operationalised measures for improvement outcomes

The third section included 4 scales (17 questions) to collect data on improvement outcomes. The respondents were asked to evaluate the change in their improvement outcomes from 1 (**Strongly disagree**) to 7 (**Strongly agree**) (Table 6.4). These questions should have high face and content validity (adequate and truly measure the concept). They were developed by Doolen et al. (2003) who used the KSA (knowledge, skills and attitude) framework from the industrial/organisational (I/O) psychology literature (Muchinsky, 2000) to measure social system outcomes. They measured 'people building' improvement results (e.g., development of knowledge, skills and attitude) rather than the 'financial related outcomes' (e.g., monetary and technical output or the number of end-products) which may not be suitable for measuring continuous improvement (Schonberger, 1982b; Meyer and Ferdows, 1990; Bond, 1999; Lillrank *et al.*, 2001; Jung and Wang, 2006; Polito and Watson, 2006; Singh and Davis, 2007; Arumugam *et al.*, 2009). The questions were empirically validated by subsequent studies (e.g., Farris, 2006; Doolen *et al.*, 2008; Farris *et al.*, 2008; Farris *et al.*, 2009) and adopted by related research to measure continuous improvement outcomes (e.g., Kosandal and Farris, 2004; Glover, 2010).

Scales	Questions and measuring method 1(Strongly disagree) -7(Strongly agree)
Continuous improvement knowledge and shop floor skills	• **Ksk1** Overall, the improvement activities increased my knowledge of what CI is • **Ksk2** In general, the improvement activities increased my knowledge of how CI should be applied • **Ksk3** Overall, the improvement activities increased my knowledge of the need for CI • **Ksk4** In general, the improvement activities increased my knowledge of my role in CI

	• **Ksk5** I can communicate new ideas as a result of participation in improvement activities • **Ksk6** I gained new production skills as a result of participation in improvement activities • **Ksk7** In general, the participation in improvement activities motivated me to perform better • **Ksk8** Overall, the improvement activities increased my work interests • **Ksk9** Overall, the improvement activities helped me and my colleagues work together to improve performance
Sense of participation (Attitude)	• **Sp1** I liked taking part in the current improvement activities • **Sp2** I would like to take part in the improvement activities in the future • **Sp3** In general, I am comfortable working with others to identify improvements on my shop floor area
Overall Improvement perceptions	• **Over1** Overall, the performance of my improvement activities was a success in my company • **Over2** Overall, my improvement activities were vital in my company
Improvement contributions(Impact on my area)	• **Cont1** My improvement activities have a positive effect on the shop floor area • **Cont2** This shop floor area improved measurably as a result of my improvement activities • **Cont3** My improvement activities have improved the performance of this shop floor area

Table 6.4 The questions developed to measure improvement outcomes

6.1.7 The translation and pilot testing

The questions were translated into Chinese using Usunier's 'Parallel Translation' (Saunders *et al.*, 2007, p385) to ensure the best match between the original English version and the Chinese version. In particular, the translation was undertaken by two bilingual master students and further reviewed by a newspaper editor to confirm the lexical and experiential meanings in the translated version (Appendix D).

The questions were then pilot tested (Flynn *et al.*, 1990) in the Chinese context to ensure the validity and the reliability of the data to be collected (Saunders *et al.*, 2007). The questions were administered to 12 shop floor workers from **Com_1** in July 2009 to indicate where improvement was needed. The questionnaire was derived from pre-tested constructs therefore the content validity and reliability had already been established by previous research. Following Bell (2010), the pilot testing in this study was aimed to obtain feedback relating to the following factors: (1) the time needed to complete the questionnaire; (2) the clarity of instructions; (3) questions clarity or ambiguity; (4) which, if any, questions the respondent felt uneasy about answering; (5) whether any major topic omission or repetition; and (6) whether the layout of the questionnaire was clear. All 12 responses were received, and no serious problems were identified in completing the questionnaire.

6.1.8 Sample and respondents selection

For survey research in social science, the sample and its size need to be designed prior data collection (De Vaus, 2002). In order to reduce the likely errors in generalising to the population, it is ideal to have a large sample size (Flynn *et al.*, 1990; Miller and Salkind, 2002). However, due to the time and cost constraints in collecting and analysing the data (Corbetta, 2003), the method of probability sampling (e.g., stratified random sampling) is widely used in survey-based research strategies (Rungtusanatham *et al.*, 2003; Saunders *et al.*, 2007; Karlsson, 2009). Based on Saunders (2007, p214), the process of this method commonly involves four stages: (1) identifying a suitable sampling frame based on research questions; (2) deciding on a suitable sample size; (3) selecting the sample based on appropriate sample; and (4) checking for the sample representativeness.

In the current study, the data collection was conducted in Guangzhou, China. The final sample consisted of nine Sino-Japanese joint ventures that were mentioned in Section 4.2.3. The sample frame is the population at sites and the intended unit of analysis is the individual employee (unit which the information is obtained and analysed) (De Vaus, 2002; Babbie, 2004).

In determining sufficient sample size, according to some previous studies (Corbetta, 2003; Saunders *et al.*, 2007), the current study used the following formula for sample size.

$$\boldsymbol{n} = p\% \times q\% \times \left(\frac{z}{e\,\%}\right)^2$$

n: the minimum sample size required
P%: is the proportion belonging to the specified category
q%: is the proportion not belonging to the specified category
z: is the *z* value corresponding to the level of confidence required
e%: is the margin of error desired

In particular, as advised by Kwaw-Mensah (2008), Ary et al. (2010), and Kalton (1983), a conservative value of 50% (0.50) was set for both *p* and *q* to obtain the maximum possible categories; the level of confidence was assigned at 95% certain and its associated *z* was 1.96; and the desired margin of error *e* was assigned at 5% (0.05). Therefore, the calculated minimum sample size of the current study was 385 (384.16).

$$\boldsymbol{n} = 0.50 \times 0.50 \times \left(\frac{1.96}{0.05}\right)^2$$
$$\boldsymbol{n} \approx 0.25 \times 1536.64$$
$$\boldsymbol{n} \approx 384.16$$

In regards to respondents, ideally the questionnaire should be completed by employees who have knowledge and experience of implementing shop floor management and continuous improvement in order to reflect the research objectives as well as minimising individual response bias. However, from a practical standpoint, it was difficult to ensure that all respondents had shop floor management and continuous improvement experience. Therefore, the respondents were randomly selected shop floor employees (including shop floor supervisors and managers).

For the sample representativeness, as suggested by some previous studies (Forza, 2002; Babbie, 2004; Saunders *et al.*, 2007), the characteristics (e.g., salary grade, gender, length of service, structure, place of work, etc.) of the respondents can be used to compare with the characteristics of the population. In the current study, the organisational structure was used to check for the representativeness between the respondents and the population from the joint ventures. The results were presented in the following Section 6.2.1.

6.1.9 The data collection and screening

The data were collected using a self-administered method (Fowler, 1995; Corbetta, 2003; Saunders *et al.*, 2007). The researcher visited each of the selected companies to distribute the questionnaires. He gave a brief introduction, outlined the objectives and explained how to complete the questionnaire (Table 6.5). 100 hard copies of the questionnaire were distributed to respondents in the 9 companies. In total, 900 questionnaires were distributed, of which 398 samples were returned, giving a response rate of 44.2%.

Company	Total responses	Study period
Com_1	**57**	**09/2009-12/2009**
Com_2	**47**	**04/2010-06/2010**
Com_3	**31**	**04/2010-06/2010**
Com_4	**36**	**04/2010-06/2010**
Com_5	**46**	**04/2010-06/2010**
Com_6	**54**	**06/2010-09/2010**
Com_7	**48**	**06/2010-09/2010**
Com_8	**49**	**09/2010-12/2010**
Com_9	**30**	**09/2010-12/2010**
Total	***398(44.2%)***	

Table 6.5 The data collection from the selected companies

The 398 completed questionnaires were analysed using SPSS 17.0. Prior to the main data analysis, it was necessary to perform data screening to ensure the accuracy of the data entry and the appropriateness of data for related statistical testing methods (Field, 2005; Pallant, 2007).

Data screening (Field, 2005) was performed to ensure the accuracy of the data entry and the appropriateness of data for related statistical testing methods (Pallant, 2007). The descriptive statistics were obtained from SPSS DESCRIPTIVES to check the accuracy of the data input and missing data (Appendix E). No out-of-range data were identified. 27 cases (6.8% of 398) were found to contain missing values, but no pattern was identified and they amounted to less than 10% of the total responses (Table 6.6). It was therefore safe to exclude them in the next stage of analysis (Tabachnick and Fidell, 2007; Rong, 2009). The remaining 371 responses were valid samples, giving an adjusted response rate of 41.2%.

Company	Deleted cases (Total cases)	Contained missing variables
Com_1	4 (57)	QC_Me_Length, QC_Mem_s (x2), Job_tit
Com_2	5 (47)	QC_Me_Length, QC_Pres, VSI_1, KnSk_3, I5S_2, KnSk_8
Com_3	1 (31)	KnSk_3
Com_5	4 (46)	Contribution_1, WSR_3, QC_comp, QC_con
Com_6	8 (54)	KnSk_1, Sp_3, Sp_1 (x2), QC_Me_Me_Times, Training, I5S_3, SDO_1
Com_8	4 (49)	KnSk_6, Contribution_2, SDO_3, QC_Me_length
Com_9	1 (30)	KnSk_1
Total	***27 (6.8% of 398)***	

Table 6.6 The detail of the deleted cases which contained missing values

Next, outliers were detected. Tabachnick and Fidell (2007, p72) defined an outlier as “a case with such an extreme value on one variable (a univariate outlier) or such a strange combination of scores on two or more variables (multivariate outlier) that it distorts statistics”. Univariate outliers (outlier on one variable alone) were identified using z-scores > ±4 (z-scores or standard scores which measures the number of standard deviations an observation is away from the mean of all observations; for large sample sizes, threshold value of 4 is accepted) (Hair *et al.*, 2010, p67). Multivariate outliers (outlier on two or more variables) were identified using threshold value > 4 (the result from a statistical test to compare the difference between the mean of two groups of variables) (Hair *et al.*, 2010). The value for multivariate outliers, used Mahalanobis distance (Mahalanobis D^2, is a distance measure based on correlations between variables) (Schwab, 2013) and divided it by the degrees of freedom ($D^2/d.f.$) (Tabachnick and Fidell, 2007; Hair *et al.*, 2010, p67). From the screening process, no value extremely exceeded the threshold value, therefore the sample had no significant problem with outliers and no transformations were required.

Further, the normality of the data set was considered. Hair et al. (2010, p40) defined the normality as "the degree to which the distribution of the sample data corresponds to a normal distribution". Thus, normal distribution describes a symmetrical and bell-shaped curve, which has the greatest frequency of corresponds in the middle and relatively smaller frequency of corresponds towards either extreme (Pallant, 2007, p57; Gravetter and Wallnau, 2009, p48). The normality of the data is determined (Pallant, 2007) based on its skewness ("peakedness" or "flatness") and kurtosis ("the balance of the distribution") (Hair *et al.*, 2010, p71). The zero values of skewness and kurtosis indicate normal distribution (Tabachnick and Fidell, 2007), and the values of skewness and kurtosis falling outside the range of ±1 indicate substantially nonnormal distribution (Hair *et al.*, 2010). The normality of the data can be assessed by either statistical (e.g., KS-test and SW-test) or graphical (e.g., frequency histograms and plots) methods (Coakes, 2005; Tabachnick and Fidell, 2007). In the current study, due to the use of the Likert-scales, the data may have been nonnormally distributed. The data were therefore also subjected to a bootstrap test in AMOS, which is robust with respect to normality (Byrne, 2010).

6.1.10 Non-response bias

Non-response bias was analysed (Armstrong and Overton, 1977; Sheikh and Mattingly, 1981). In survey research, non-response is a ubiquitous problem (Burkell, 2003), and is an important potential source of bias (Lindner *et al.*, 2001; Barclay *et al.*, 2002). Survey non-response may be defined as "the discrepancy between the group approached to complete a survey and those who eventually provide data" (Burkell, 2003, p241); and non-response bias is "the difference between the answers of non-respondetns and respondents" (Lambert and Harrington, 1990, p5). This may be caused by the preferences of the respondents (Pearl and Fairley, 1985) or a selective sample that is accessible to the research (Blair and Zinkhan, 2006). The occurance of non-response bias can jeopardise the validity of studies (de Winter *et al.*, 2005).

Some researchers (e.g., Malhotra and Grover, 1998; Krenzke *et al.*, 2005) have suggested that efforts to stimulate a higher response rate may protect the validity against non-response bias, but it requires additional costs and time (Lambert and Harrington, 1990). According to some researchers, there are at least three ways to estimate non-response after the data collection: (1) the use of the extrapolation methods to compare the early to late respondents (Armstrong and Overton, 1977; Lindner *et al.*, 2001); (2) the comparison with known values for the population (Barclay *et al.*, 2002); or (3) to determine respondents and non-respondents based on subjective estimates differences (e.g., socioeconomic) (Brown, 1969; Pearl and Fairley, 1985).

This study adopted the method (3) based on subjective estimates to determine respondents and non-respondents. According to Pearl and Fairley (1985), people who have a strong feeling about the issues investigated are more likely to respond. Thus, this study assumed that the respondents who had significant experience (say, ≥5 years) were more likely to respond. Following this, the potential non-response bias could be assessed by comparing the questionnaires that were completed by the respondents who had little improvement experience (<5 years, n=100) and those with long improvement experience (≥5 years, n=271). The F-statistic (F-test) was used to compare the two groups of respondents in terms of the *quality* and *quantity* of their improvements (as advised in Section 6.1.4). The F-statistic is the ratio of two sample variances (Mendez-Vilas, 2012, p164). It provides a measure of the probability that they have differences and the threshold value (*p*) below 0.05 can indicate the differences are significant with a 95% confidence interval. Table 6.7 shows that all of the significance values were above the threshold value of 0.05. This indicates that the differences between these two groups of respondents were not statistically significant. It, therefore suggests that non-response bias was not a problem with regard to the data collected in this study.

	Characteristics of the respondents	F-statistics	Significance *p*
Quantity (QCCs)	**QC_Meet_Times**	1.005	0.317
	QC_Met_Length	0.012	0.911
Quality (QCCs)	**QC_Comp**	1.591	0.208
	QC_Pres	0.008	0.985
Quantity (*Teians*)	**Tn_Sub**	0.330	0.856
Quality (*Teians*)	**Tn_Acc**	0.555	0.457

Table 6.7 F-test to compare respondents based on improvement experience (sample size=371)

6.2 Descriptive Data Analysis

This section presents the general demographic descriptions, demographic features of the respondents based on the implementation of the four building block shop floor management tools, the two improvement practices and the improvement outcomes.

6.2.1 Demographic description

Table 6.8 shows the sample distribution of survey participants' qualifications. 60.4%, of the respondents reported that they did not attend university; followed by 38.3% that held a bachelor degree; and a further 1.3% had a masters degree or above. All employees, irrespective of prior qualifications were encouraged to make individual improvement suggestions as well as participating in group improvement activities.

Qualification	Frequency	Percentage (%)
Secondary/college or below	224	60.4
Bachelor Degree	142	38.3
Masters Degree or above	5	1.3
Total	***371***	***100***

Table 6.8 Sample distribution on participants' qualification

In regards to the working position in the organisation, Table 6.9 indicates that the line supervisor to shop floor worker was 1:7.16 (44 line supervisors to 315 shop floor workers). This indicated that there was no significant difference between the proportions of respondents in the ratio of line supervisors to shop floor workers and the data obtained from the joint ventures official documents for all employees (about 1:8). Additionally, Table 6.9 also exhibits that majority of the respondents (60.4%) were shop floor operatives, 11.9% were line supervisors and 3.2% managers. Improvement activities were therefore not dominated by the top and middle management. This is in agreement with the ideas of Caffyn (1999), Bodek (2002), Bessant and Caffyn (1997) who suggested that the employees' total involvement was one of the critical enablers for implementing continuous improvement.

Work title	Frequency	Percentage (%)
Shop floor worker	315	84.9
Line supervisor	44	11.9
Manager	22	3.2
Total	***371***	***100***

Table 6.9 Sample distribution on participants' work title

Work improvement experience were categorised into four groups as shown in Table 6.10 and Table 6.11. Table 6.10 shows that the majority of the respondents (69.3% = 50.4% + 13.2%+ 5.7%) had more than five years of experience working in the same organisation. 13.2% had more than ten years' experience and a further 5.7% had more than 15 years' experience. Table 6.11 shows that 100 out of 371 respondents (27.0%) had less than five years of experience of implementing continuous improvement activities. However, the rest of the respondents (73.1% = 50.7% + 20.5% + 1.9%) had at least five years' experience. 83 out of 371 respondents (22.4% = 20.5% + 1.9%) had more than ten years' experience.

Years in the organisation	Frequency	Percentage (%)
Less than 5 years	114	30.7
Between 5 to 10 years	187	50.4
Between 10 to 15 years	49	13.2
More than 15 years	21	5.7
Total	***371***	***100***

Table 6.10 Sample distribution on participants' working experience

Years of continuous improvement activities	Frequency	Percentage (%)
Less than 5 years	100	27.0
Between 5 to10 years	188	50.7
Between 10 to 15 years	76	20.5
More than 15 years	7	1.9
Total	***371***	***100***

Table 6.11 Sample distribution on participants' improvement experience

Table 6.12 shows that almost half of the participants had participated in QCCs (43.7%). Based on the previous findings (Inoue, 1985; Lillrank and Kano, 1989; Harrington, 2006), the large number of the QCC improvement practices was likely to be due to the source of the survey sample that was drawn from the organisations whose improvements were mainly made on a department-wide/company-wide basis for long-term changes. However, the results also show an equal proportion of respondents (46.9%) had participated in both QCCs and *Teians*.

Improvement focuses	Frequency	Percentage (%)
QCC	162	43.7
Teians	35	9.4
About the same	174	46.9
Total	***371***	***100***

Table 6.12 Sample distribution on participants' improvement focuses

Table 6.13 indicates that 81.7% of the respondents were QCC group members, and 18.3% of the respondents were QCC group leaders or facilitators. Table 6.14 shows that the majority of the QCC groups had 5 to 15 members. Almost two-thirds (61.7%) of the respondents reported that their QCC groups had 5 to 10 members, and another one-third (34.0%) had 10 to 15 members. Only a small portion of the respondents had very small or large QCC groups (0.3% and 4.0% respectively). This result is consistent with other studies (Lillrank and Kano, 1989; Honda Motor, 1998).

QCC group position	Frequency	Percentage (%)
Member	303	81.7
Leader/facilitator	68	18.3
Total	***371***	***100***

Table 6.13 Sample distribution on participants' QCC group position

QCC group size	Frequency	Percentage (%)
Less than 5 persons	1	0.3
Between 5 to10 persons	229	61.7
Between 10 to 15 persons	126	34.0
More than 15 persons	15	4.0
Total	***371***	***100***

Table 6.14 Sample distribution on participants' QCC group size

Table 6.15 indicates that 146 out of 371 (39.4%) participants revealed that QCC members were mostly from the same area, 78 (21.0%) reported that most participants were from different areas, and the rest of the 147 (39.6%) the group was evenly distributed. Wood and Munshi (1991), suggest this might be because the organisations focused upon department-wide/company-wide changes which required cross-functional improvement ideas.

QCC membership	Frequency	Percentage (%)
Mainly from the same area	146	39.4
Mainly from the different areas	78	21.0
About the same	147	39.6
Total	***371***	***100***

Table 6.15 Sample distribution on participants' QCC membership

The frequency of improvement training was categorised as shown in Table 6.16. More than half (59.8% = 59.0% + 0.8%) of the respondents did not attend regular training (less than once in every two months), only a small number (24.8%) of the respondents trained about once every two months and a lot less (15.3% = 12.9% + 2.4%) trained at least once per month. Yasuda (1989) indicated that continuous improvement, especially *Teians*, requires hands-on improvement knowledge that comes from first-hand working experience.

Training for improvement in the past 12 months	Frequency	Percentage (%)
None (0)	3	0.8
Less than once every two months (1-5)	219	59.0
About once every two months (6-10)	92	24.8
About once every months (11-15)	48	12.9
More than once every month (>15)	9	2.4
Total	***371***	***100***

Table 6.16 Sample distribution on participants' improvement training

6.2.2 The implementation of the four shop floor management tools

Table 6.17 shows the respondents' shop floor management implementation experience. It comprises the *5S practice* (**I5S**), *standard operations* (**SDO**), *waste removal* (**WSR**) and *visual management* (**VSI**).

	I5S	SDO	WSR	VSI	Note:	
Mean	5.35	5.02	4.23	4.52	**1-"never use"**	**5-"use frequently"**
Median	5.40	5.00	4.33	4.75	**2-"use very rarely"**	**6-"use very frequently"**
Min	1.40	2.00	1.00	1.75	**3-"use rarely"**	**7-"always use"**
Max	7.00	6.75	7.00	6.50	**4-"use occasionally"**	**n=371**

Table 6.17 The overall frequency of use of the four building block tools

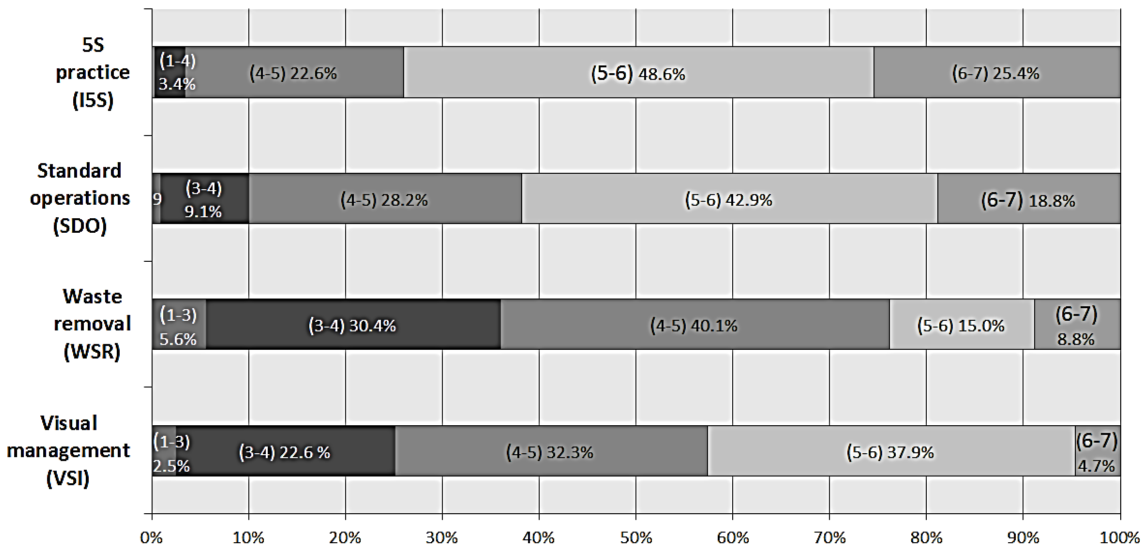


Figure 6.2 Mean overall frequency use of the four building block tools

The respondents reported a wide variation in *5S practice* (**I5S**). From Table 6.17, the responses spanned from 1.4 (below "use very rarely") to 7 ("always use") on a 7-point Likert scale. Nevertheless, as shown in Figure 6.2, only 3.4% of the respondents rated it below the midpoint of 4 ("use occasionally"). However, 48.6% of respondents rated it between 5 and 6 ("use frequently" and "use very frequently") and a further 25.4% of respondents rated it between 6 and 7 ("use very frequently" and "always use"). Thus, the mean response was above 5 ("use frequently") at 5.35, which implied a high frequency of use of *5S practice* for the majority of respondents.

The respondents produced a wide range of responses to the use of *standard operations* (**SDO**) question. Table 6.17 shows that the lowest figure was 2 ("use very rarely") and the highest was above 6.75 ("use very frequently") on a 7-point response scale. However, the overall mean was above the midpoint of 4 ("use occasionally") at 5.02. Figure 6.2 reveals that in total 42.9% of respondents rated it between 5 and 6 ("use frequently" and "use very frequently") and a further 18.8% of respondents rated it 6 and above (between "use very frequently" and "always use"). Therefore, the figures obtained from the case companies showed a high frequency of use of *standard operations*.

The results show a lower frequency of use of *waste removal* (**WSR**) and *visual management* (**VSI**). It is apparent from Table 6.17 that the overall means for *waste removal* (**WSR**) and *visual management* (**VSI**) were less than 5 (below "use frequently") at 4.23 and 4.52 respectively. However, two-thirds of the respondents actually admitted that they have implemented these two tools more than occasionally. As shown in Figure 6.2, on the 7-point response scale, 63.9% (40.1%+15%+8.8%) of the total responses observed were above the midpoint of 4 (above "use occasionally") for *waste removal* (**WSR**) and 74.9% (32.3% + 37.9% + 4.7%) for *visual management* (**VSI**). These results suggested that, for the participating organisations, most, although not all, of the shop floor respondents, had implemented *waste removal* and *visual management* more than occasionally.

6.2.3 The two improvement practices

Table 6.18 shows the respondents' QCC outcomes. It comprises the QCC *meeting time* (**QC_Me_Times**), *meeting length* (**QC_Me_Length**), the *number of completed themes* (**QC_Comp**) and the *number of presented themes* (**QC_Pres**).

	QC_Me_Times	QC_Me_Length	QC_Comp	QC_Pres	Note:
Mean	3.38	0.68	1.69	0.63	**QC_Me_Times (times/month)**
Median	3.00	0.50	2.00	1.00	**QC_Me_Length (hour)**
Min	1	0.50	0	0	**n=371**
Max	7	1.50	4	4	

Table 6.18 The overall frequency of QCC implementation

For *QCC meeting time* (**QC_Me_Times**) (Figure 6.3), a large proportion of (55.7% + 11.6% = 67.3%) of the respondents reported that they usually meet at least three times per month for QCCs, whilst the rest (32.6%) stated that they met no more than twice per month.

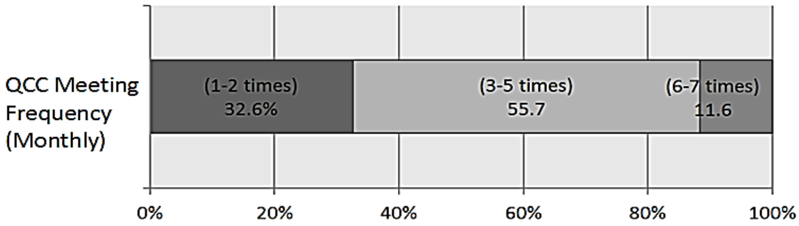


Figure 6.3 The frequency of QCC meetings per month (average)

For the *length of each QCC meeting* (**QC_Me_Length**) (Figure 6.4), almost two-thirds (65.5%) of the respondents said that they usually spent less than one hour on each QCC meeting, whilst the rest (33.7% + 0.8% = 34.5%) met for at least one hour.

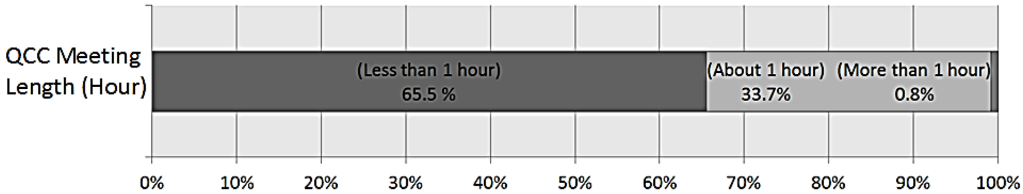


Figure 6.4 The QCC meeting length (average)

For the number of the *completed QCC themes* (**QC_Comp**) (Figure 6.5), more than half of the respondents (30.2% + 18.3% + 3.8% = 52.3%) completed 2 or more QCC themes on an annual basis. On comparison, 38.5% of the respondents only completed 1 and a further 9.2% did not complete any.

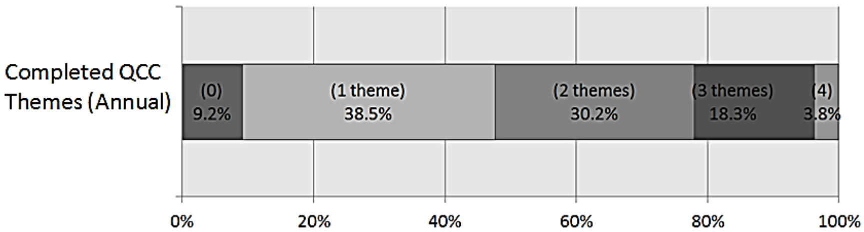


Figure 6.5 The number of completed QCC themes (2009)

For the number of the *presented QCC themes* (**QC_Pres**) (Figure 6.6), 47.4% of the respondents did not make any QCC presentations on an annual basis, whilst the rest 52.6% (43.4% + 8.6% + 0.6%) presented at least once. 9.2% (8.6%+0.6%) of the respondents presented twice or more.

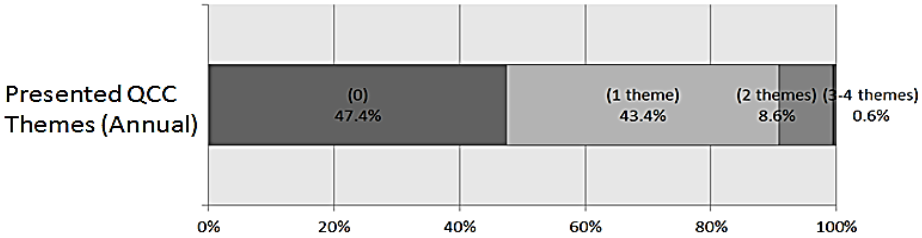


Figure 6.6 The number of presented QCC themes (2009)

On the other hand, the implementation of *Teians* was measured based on individual respondent's *Teian* submission rate (**Tn_Sub**) and acceptance rate (**Tn_Acc**) (Table 6.19).

	Tn_Sub	Tn_Acc	Note: n=371
Mean	9.43	4.31	
Median	10.00	4.00	
Min	0	0	
Max	18	9	

Table 6.19 The number of *Teians* submitted and accepted

For the *Teians* submission rate (**Tn_Sub**) (Figure 6.7), the majority of the respondents (53.1% + 20.8% = 73.9%) submitted 7 or more (at least one in every two months), and the rest (26.1%) submitted 6 or less in the same period of time (less than one in every two months).

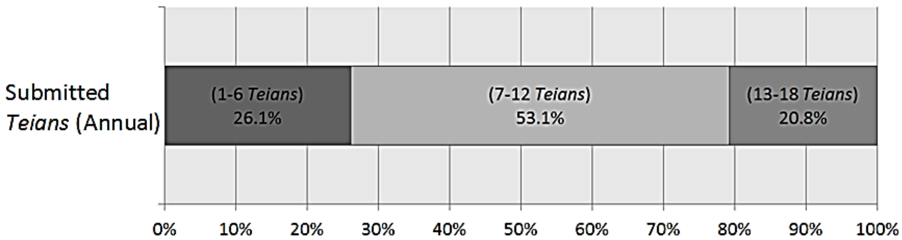


Figure 6.7 The number of submitted *Teians* (2009)

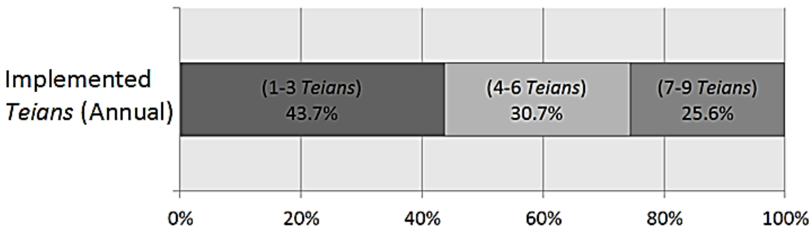


Figure 6.8 The number of accepted *Teians* (2009)

For the number of the *Teians* acceptance rate (**Tn_Acc**) (Figure 6.8), 25.6% of the respondents had 7 to 9 *Teians* accepted on an annual basis (at least one in every two months), 30.7% had 4 to 6 *Teians* accepted (no more than one in every two month), and the rest 43.7% had no more than 3 accepted.

6.2.4 The improvement outcomes

Table 6.20 shows the respondents' improvement outcomes. It comprises the *knowledge and skills* (**Ksk**), *sense of participation* (**Sp**), *overall perceptions* (**Over**) and *contributions* (**Cont**).

	Ksk	Sp	Over	Cont	Note:	
Mean	5.30	5.65	5.75	5.60	**1-"strongly disagree"**	**5-"slightly agree"**
Median	5.33	5.66	6.00	5.67	**2-"disagree"**	**6-"agree"**
Min	3.00	1.67	1.50	1.33	**3-"slightly disagree"**	**7-"strongly agree"**
Max	7.00	7.00	7.00	7.00	**4-"neither agree nor disagree"**	

Table 6.20 The overall perception of the improvement outcomes

The shop floor respondents reported consistently positive perceptions of their long-term outcome measures. As shown in Table 6.20, the mean response for all outcomes were found to be over 5 ("slightly agree"). However, the results showed a fairly wide range of variation in responses on the 7-point response scale. In particular, the minimum observed response was 3 ("slightly disagree") for *knowledge and skills* (**Ksk**), and even lower for *sense of participation* (**Sp**), *overall perceptions* (**Over**) and *contributions* (**Cont**) at 1.67, 1.50 and 1.33 respectively (below "disagree").

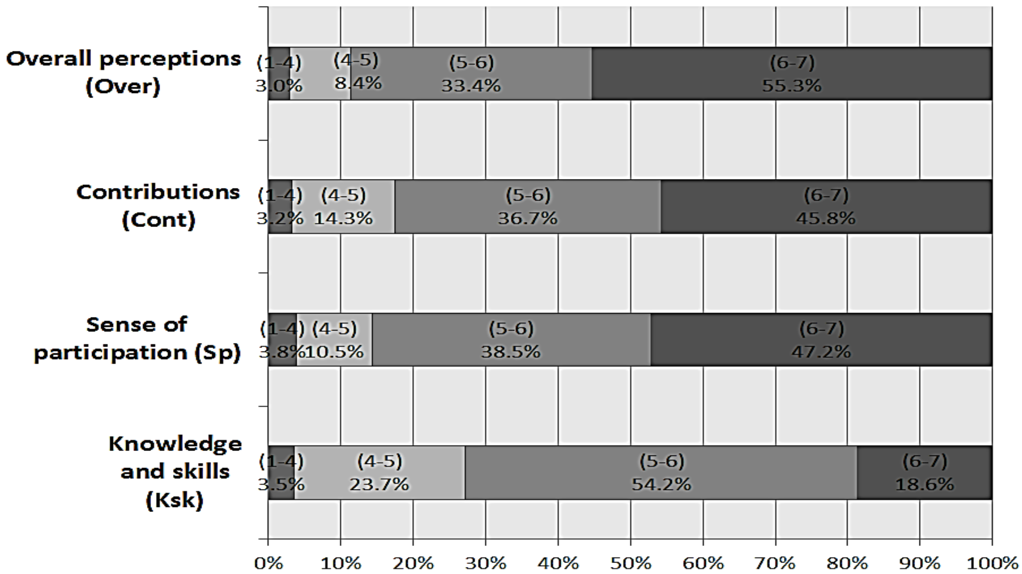


Figure 6.9 Mean perception of improvement outcomes

As also shown in Figure 6.9, for all outcomes, the cumulative percentage for negative perceptions was not high. In particular, no more than 4% of the respondents who selected 4 (“neither agree nor disagree”) or below for all outcomes, whilst the majority of respondents reported positive perceptions. It was found that 72.8% (54.2%+18.6%) of respondents selected 5 (“slightly agree”) for *knowledge and skills* (**Ksk**), and almost half of the respondents rated 6 (“agree”) for *sense of participation* (**Sp**), *contributions* (**Cont**) and *overall perceptions* (**Over**) (47.2%, 47.2% and 55.3% respectively). These results suggest that, for the participating organisations, most, although not all, of the shop floor respondents viewed the improvement outcomes positively.

6.3 Factor Analysis of Survey Scales

Following the data screening and demographic description, SPSS was used to perform factor analysis to assess the construct validity (Emory and Cooper, 1991) .

6.3.1 Univariate analysis

EFA was used to identify the underlying structure and examine the factor loadings of the 33 Likert-scale variables (16 answers for the use of shop floor management tools and 17 answers for improvement outcomes). In the *first* step, the suitability of the data for factor analysis was assessed. The univariate analysis revealed that the data were not normally distributed, so a ‘bootstrap’ analysis was required in later step to ensure the reliability of the results.

6.3.2 Preliminary analyses

The *second* step identified that the data had a sampling adequacy for factor analysis (the KMO test gave a result of 0.807), there were correlations between the variables (Barlett’s Test of Sphericity produced a significant result, $p<0.001$) (Table 6.21); and they were free from multicollinearity problems (the determinant of the Correlation Matrix was 0.01).

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.807
Bartlett's Test of Sphericity	Approx. Chi-Square	3138.157
	df	528
	Sig.	.000

Table 6.21 KMO and Bartlett's Test (SPSS output)

6.3.3 Factor extraction

In the *third* step, a PCA analysis was conducted for factor extraction. According to Johnson and Wilchern (2007), PCA is a preferable method for non-normal scaling data of the type obtained in this study. Furthermore, PCA is recommended for an empirical summary of the data set (a reduction of the correlated observed variables) rather than other factor analytical methods which are more suitable for developing a theoretical solution uncontaminated by unique and error variability (Tabachnick and Fidell, 2007). Consequently, PCA was selected for factor extraction.

Component	Total	% of Variance	Cumulative %
1	5.469	16.572	16.572
2	2.632	7.977	24.549
3	2.430	7.364	31.912
4	1.989	6.027	37.939
5	1.837	5.567	43.506
6	1.545	4.683	48.189
7	1.277	3.870	52.059
8	1.156	3.503	55.562
9	*.934*	*2.830*	*58.392*
10	*.865*	*2.621*	*61.014*
Extraction Method: Principal Component Analysis.			

Table 6.22 Variance explained by components with eigenvalues exceeding 1 (SPSS output)

The PCA results (Table 6.22) revealed that there were eight components with an Eigenvalue exceeding 1, explaining 16.572%, 7.977%, 7.364%, 6.027%, 5.567%, 4.683%, 3.870% and 3.503% of the variance respectively and contributing to the accumulative variance of 55.562%. Cattell's screen test (Cattell, 1966), also suggested eight components, as the plot levelled off from the ninth component (Figure 6.10).

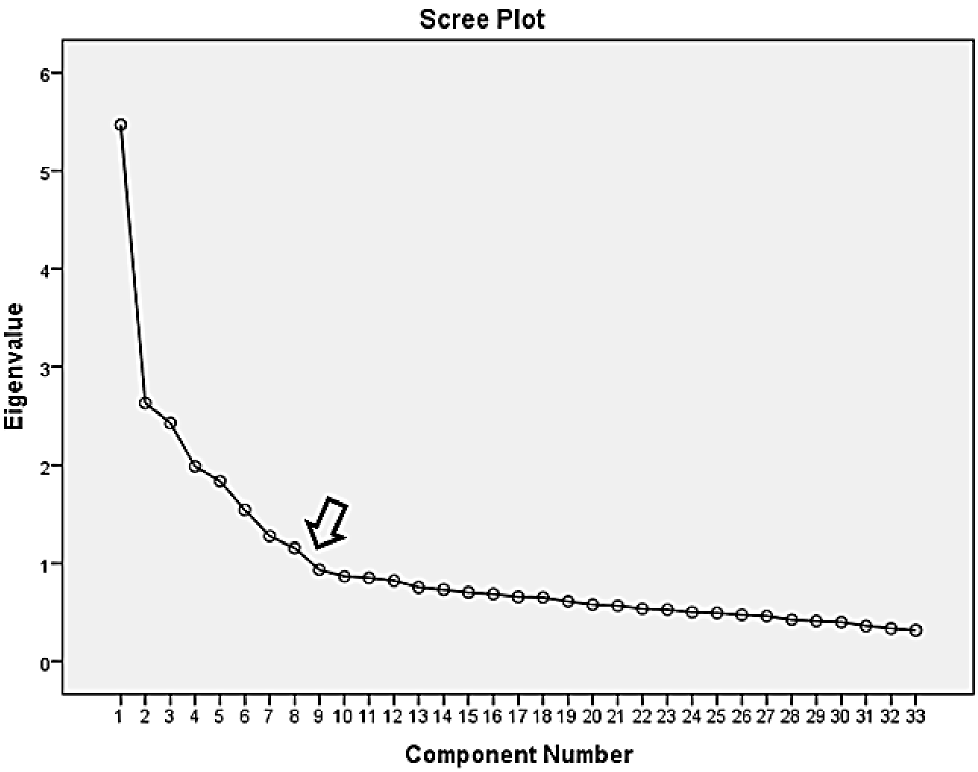


Figure 6.10 Screen plot (SPSS output)

6.3.4 Factor rotation

In the *fourth* step, Varimax rotation (a type of Orthogonal rotation) was applied. It simplified the factors by minimising cross-products loadings to improve the interpretability of the retained components. The rotated results indicated that the 33 variables were loaded on eight factors (Table 6.23).

	Rotated Component Matrix								Component Matrix								
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	Com.
Cont2	**.714**	.026	.039	.027	.089	.061	.044	.070	.493	.143	-.061	-.047	-.304	-.104	.382	.115	.531
Over1	**.676**	.143	.007	.179	-.020	.161	.043	.020	.549	.205	-.091	-.166	-.269	.017	.235	.177	.538
Cont1	**.674**	.079	.179	.150	.094	-.012	.018	.018	.580	.061	-.089	-.100	-.291	-.098	.269	-.016	.525
Over2	**.665**	.213	-.051	.170	.106	.004	.087	.039	.571	.213	-.177	-.089	-.189	-.157	.214	.154	.540
Cont3	**.595**	.123	.235	.184	-.006	-.006	-.065	-.033	.533	.044	-.123	-.193	-.272	.000	.206	-.092	.464
KSk9	**.451**	.168	.216	.173	.136	-.104	.248	-.028	.581	-.113	-.089	-.043	-.043	-.156	.115	.031	.400
I5S2	.078	**.722**	.023	.098	.129	-.017	.019	.050	.412	.294	-.306	-.039	.437	.031	-.066	-.102	.558
I5S4	-.012	**.720**	.074	.095	-.037	.065	.052	.060	.358	.219	-.304	-.074	.463	.211	-.098	-.055	.545
I5S3	.138	**.671**	.063	.026	.107	-.064	.026	.019	.401	.226	-.313	-.064	.403	.002	.030	-.115	.491
I5S1	.171	**.669**	.068	-.053	-.004	.067	-.021	-.007	.358	.264	-.277	-.145	.390	.137	.125	-.081	.489
I5S5	.189	**.639**	-.110	.155	-.031	.002	.076	-.013	.390	.279	-.352	-.160	.306	.034	-.062	.096	.487
KSk2	-.074	.005	**.708**	.111	.096	.068	.144	.043	.372	-.408	.230	.110	.084	.239	-.042	-.346	.556
KSk1	.201	.079	**.702**	.125	.043	-.024	.139	.048	.535	-.382	.062	.034	-.017	.184	.092	-.316	.580
KSk4	.165	.002	**.700**	.079	-.022	.049	.117	-.120	.437	-.420	.169	-.122	-.020	.205	.113	-.296	.554
KSk3	.100	.044	**.666**	-.004	-.039	-.022	.198	.010	.389	-.457	.075	.020	.065	.212	.138	-.250	.497
Sp2	.274	.027	.018	**.775**	.006	.050	.150	.041	.563	.030	-.050	-.076	-.345	-.009	-.478	.174	.704
Sp3	.172	.133	.086	**.747**	.107	.031	-.053	.016	.518	.136	-.047	-.091	-.261	-.007	-.508	-.066	.628
Sp1	.190	.158	.126	**.675**	.122	.012	.007	.050	.546	.094	-.060	-.041	-.208	-.010	-.437	-.061	.551
KSk8	.185	-.001	.135	**.446**	-.007	.051	.219	-.031	.501	-.234	.075	-.068	-.156	.085	-.221	.008	.396
VSI2	-.014	.033	.019	.129	**.724**	.094	.017	.046	.275	.252	.367	.292	.116	-.361	-.123	-.187	.553
VSI1	.056	.097	-.048	.107	**.720**	.048	.102	-.097	.313	.238	.334	.167	.187	-.469	-.086	-.102	.567
VSI4	.122	-.049	.148	.018	**.685**	.189	.009	.095	.328	.207	.440	.310	.028	-.256	.071	-.205	.553
VSI3	.110	.062	-.024	-.040	**.642**	.070	.069	.029	.258	.236	.290	.248	.144	-.370	.077	-.099	.441
SDO3	.019	.019	.061	.019	.188	**.743**	-.121	-.041	.150	.388	.565	-.056	.037	.331	.042	.023	.609
SDO1	-.082	.100	.049	.174	-.037	**.721**	.060	-.066	.180	.242	.444	-.133	.106	.451	-.145	.191	.578
SDO4	.105	.060	-.054	-.055	.131	**.714**	.053	.037	.179	.370	.464	.011	.080	.304	.133	.227	.552
SDO2	.075	-.111	.018	-.014	.107	**.643**	-.064	-.028	.087	.281	.508	-.043	-.069	.276	.096	.107	.448
KSk6	.011	.071	.185	.047	.094	.021	**.787**	.040	.406	-.438	.126	.212	.315	-.058	-.027	.389	.672
KSk5	.114	.029	.237	.044	.089	-.007	**.776**	-.025	.455	-.482	.135	.142	.247	-.097	.037	.365	.683
KSk7	.056	.032	.194	.065	.027	-.086	**.775**	-.002	.391	-.512	.048	.152	.248	-.101	-.020	.378	.655
WSR3	-.059	.080	-.044	-.010	.009	-.012	.007	**.822**	.033	.157	-.279	.712	-.067	.268	-.006	.032	.688
WSR1	.097	.094	.014	-.037	.054	-.016	-.024	**.812**	.138	.181	-.281	.686	-.119	.235	.109	-.015	.683
WSR2	.053	-.065	.007	.120	.004	-.060	.027	**.770**	.112	.062	-.243	.660	-.250	.202	-.042	.040	.618

Table 6.23 The factor loadings of measures for improvement outcomes from SPSS

The items to measure the use of shop floor management tools were loaded on to the original four factors as developed. They were *Implementation of 5S practices* (**I5S**), *Use of the standard operations* (**SDO**), *Implementation of waste removal* (**WSR**), and *Use of visual management* (**VSI**).

However, the items to measure the improvement implementation were loaded differently. *Improvement of Knowledge and Skills* (**KSk**) were loaded separately onto two different factors. According to Doolen et al. (2003), the items from **KSK1** to **KSK4** were originally developed to measure knowledge of improvement. These 4 items were renamed *improvement knowledge* (**IpKn**). The items from **KSK5** to **KSK7** were originally developed to evaluate shop floor skills. They were named *shop floor skills* (**SFK**).

The 3 *Improvement Contribution* (**Cont**) items and the 2 *Overall Improvement Perceptions* (**Over**) items were loaded together. A further item from the measure of *Improvement of Knowledge and Skills* (**KSk9**) was also loaded onto this component. These 5 items were grouped together and given a new name: *shop floor performance* (**SFP**).

All 3 *Sense of participation* (**Sp**) items were loaded together into a single component. A further item from the measure of *Improvement of Knowledge and Skills* (**KSk8**) was loaded onto this component. These 4 items were grouped together and given a new name: *sense of participation* (**Sens**).

The items to measure *Improvement of Knowledge and Skills* (**KSk**) were loaded separately onto two different components. According to Doolen et al. (2003), the items from **KSK1** to **KSK4** were originally developed to measure knowledge of improvement. These 4 items were renamed *improvement knowledge* (**IpKn**). The items from **KSK5** to **KSK7** were originally developed to evaluate shop floor skills. They were named *shop floor skills* (**SFK**).

All 33 items were retained with high convergent validity (the items within the same scale are correlated, cross-loadings > 0.4) and discriminant validity (the items between different scales are distinct, cross-loading < 0.3) (defined by Hair *et al.*, 2010; Gaskin, 2011; Stangor, 2011). In addition, the revised scales were rational and in line with previouse research (Doolen *et al.*, 2003). The revised scales were listed as above (Table 6.24): *shop floor performance* (**SFP**); *Implementation of 5S practices* (**I5S**); *improvement knowledge* (**IpKn**); *sense of participation* (**Sens**); *Use of visual management* (**VSI**); *Use of the standard operations* (**SDO**); *shop floor skills* (**SFK**) and *Implementation of waste removal* (**WSR**).

	Rotated loadings	Eigenvalues	% Of Variance	Cumulative %
Shop floor performance (**SFP**)		**5.469**	**16.572**	**16.572**
Cont2	.714			
Over1	.676			
Cont1	.674			
Over2	.665			
Cont3	.595			
KSk9	.451			
Implementation of 5S practice (**I5S**)		**2.632**	**7.977**	**24.549**
I5S2	.722			
I5S4	.720			
I5S3	.671			
I5S1	.669			
I5S5	.639			
Improvement knowledge (**IpKn**)		**2.430**	**7.364**	**31.912**
KSk2	.708			
KSk1	.702			
KSk4	.700			
KSk3	.666			
Sense of participation (**Sens**)		**1.989**	**6.027**	**37.939**
Sp2	.775			
Sp3	.747			
Sp1	.675			
KSk8	.446			
Use of visual management (**VSI**)		**1.837**	**5.567**	**43.506**
VSI2	.724			
VSI1	.720			
VSI3	.685			
VSI4	.642			
Use of the standard operations (**SDO**)		**1.545**	**4.683**	**48.189**
SDO3	.743			
SDO1	.721			
SDO4	.714			
SDO2	.643			
Shop floor skills (**SFK**)		**1.277**	**3.870**	**52.059**
KSk6	.787			
KSk5	.776			
KSk7	.775			
Implementation of waste removal (**WSR**)		**1.156**	**3.503**	**55.562**
WSR3	.822			
WSR1	.812			
WSR2	.770			

Table 6.24 The revised scales with factor loadings

6.4 Reliability of the Revised Scales

Following factor analysis, it is important to assess the scales' internal consistency to ensure that all the designed and developed questions 'hang together' and measure the underlying construct (Field, 2005). Cronbach's (1951) alpha was calculated to show the reliability of the factors. The following Table 6.25 presents the resulting values and the associated minimum inter-item correlation values generated by SPSS.

According to Nunnally and Bernstein (1994), Cronbach's alpha coefficient as a scale should reach 0.7 or above to indicate the internal consistency of the containing items. However, in the case of a small number of items in the scale (e.g. fewer than 10), optimal mean inter-item correlation values that range from 0.2-0.4 are acceptable (Pallant, 2007). Hence, the scales to measure the use of shop floor management tools remained the same.

Factors	Cronbach's Alpha
SFP	0.767
I5S	0.744
IpKn	0.716
Sens	0.712
VSI	0.679 (* 0.287)
SDO	0.686 (* 0.291)
SFK	0.765
WSR	0.734

Table 6.25 Cronbach's Alpha Values for Revised Survey Scales (* minimum inter-item correlation value)

The revised scales to measure improvement implementation are presented in Table 6.26. They, based on the factor analysis results, had high construct validity (the questions actually measure what they are designed to measure, Hair *et al.*, 2010; Stangor, 2011).

Revised Scales	Item List
Shop floor performance **(SFP)**	• **Over1**: Overall, the performance of my improvement activities was a success in my company • **Over2**: Overall, my improvement activities were vital in my company • **Cont1**: My improvement activities have a positive effect on the shop floor area • **Cont2**: This shop floor area improved measurably as a result of my improvement activities • **Cont3**: My improvement activities have improved the performance of this shop floor area • **KSk9**: Overall, the improvement activities helped me and my colleagues work together to improve performance
Shop floor skills **(SFK)**	• **KSk5**: I can communicate new ideas as a result of participation in improvement activities • **KSk6**: I gained new production skills as a result of participation in improvement activities • **KSk7**: In general, the participation in improvement activities motivated me to perform better
Sense of participation **(Sens)**	• **Sp1**: I like taking part in the current improvement activities • **Sp2**: I would like to take part in the improvement activities in the future • **Sp3**: In general, I am comfortable working with others to identify improvements on my shop floor area • **KSk8**: Overall, the improvement activities increased my work interests
Improvement Knowledge **(IpKn)**	• **KSk1**: Overall, the improvement activities increased my knowledge of what CI is • **KSk2**: In general, the improvement activities increased my knowledge of how CI should be applied • **KSk3**: Overall, the improvement activities increased my knowledge of the need for CI • **KSk4**: In general, the improvement activities increased my knowledge of my role in CI

Table 6.26 The revised measures for improvement outcomes

6.5 Summary

This chapter discussed the data collection and screening procedures. The data were collected from 9 Sino-Japanese automotive joint ventures. A questionnaire was derived from pretested questions. It was distributed using the self-administered method. 900 questionnaires were distributed of which 398 were returned. However, 27 (6.8%) contained missing values, so 371 were valid samples, giving a response rate of 41.2%. Finally, SPSS was used to assess the construct validity and summarise the patterns of the collected samples.

In the next chapter, the theoretical model will be developed. In addition, structural equation modelling with path analysis will be used to analyse the data, shape the proposed theoretical model, and test the hypotheses.

Chapter 7 Structural Path Modelling Analysis

This chapter describes the use of a structural equation modelling (SEM) and path analysis method for hypotheses testing. It consists of 4 parts. Section 7.1 - 7.2 detail a five-step process (Schumacker and Lomax, 2004) to specify and estimate two SEM path models. Section 7.3 illustrates a bootstrapping procedure to validate the reliability of the model fit indices and the accuracy of the path estimates. Finally, Section 7.4 presents the results and explains the use of the path models for hypotheses testing.

7.1 Hypothesised Model (a) for Testing H1

Two structural path models were developed to test the cause and effect relationships. Model (a) (Figure 7.1) was developed to test **H1** as defined in Section 4.3.2 (Figure 4.9).

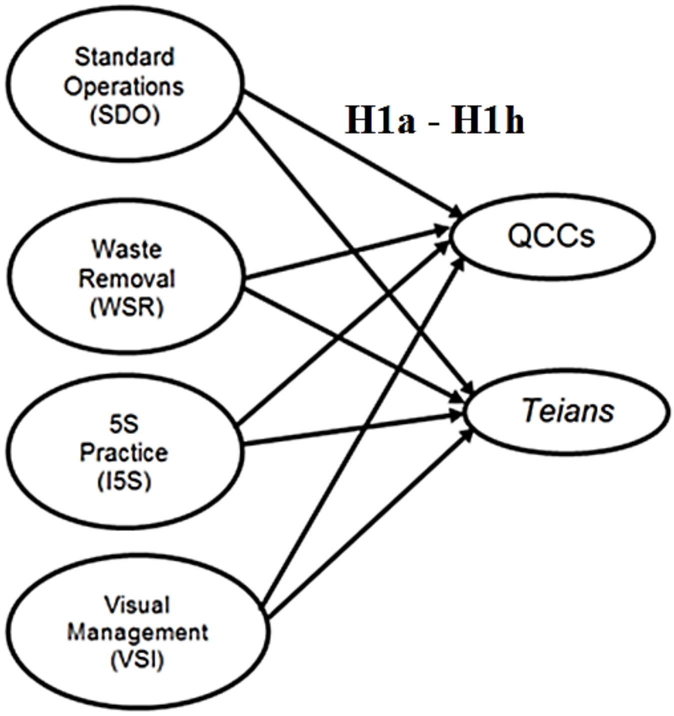


Figure 7.1 Hypothesised model (a) for H1

H1 was expanded to take into account the relationship between the four building block shop floor management tools and the two improvement practices. This resulted in the following eight sub-hypotheses (Table 7.1).

H1. The building block shop floor management tools have positive effects on the improvement practices
H1a Implementation of standard operations has positive effects on QCCs H1b Implementation of waste removal has positive effects on QCCs H1c Implementation of 5S practice has positive effects on QCCs H1d Implementation of visual management has positive effects on QCCs
H1e Implementation of standard operations has positive effects on *Teians* H1f Implementation of waste removal has positive effects on *Teians* H1g Implementation of 5S practice has positive effects on *Teians* H1h Implementation of visual management has positive effects on *Teians*

Table 7.1 the sub-hypotheses for H1

The paths in this model were then specified, identified, estimated, tested and modified by using a five-step PA process (see Figure 5.12 in Section 5.3.3).

7.1.1 Model specification for model (a)

A full PA model was created by using the AMOS Graphics which used SEM's path symbol notation (see Figure 5.9 in Section 5.3.1). The hypothesised path model (a) consisted of 6 latent variables and 9 inferred observed variables. Figure 7.2 depicts the hypothesised path model (a).

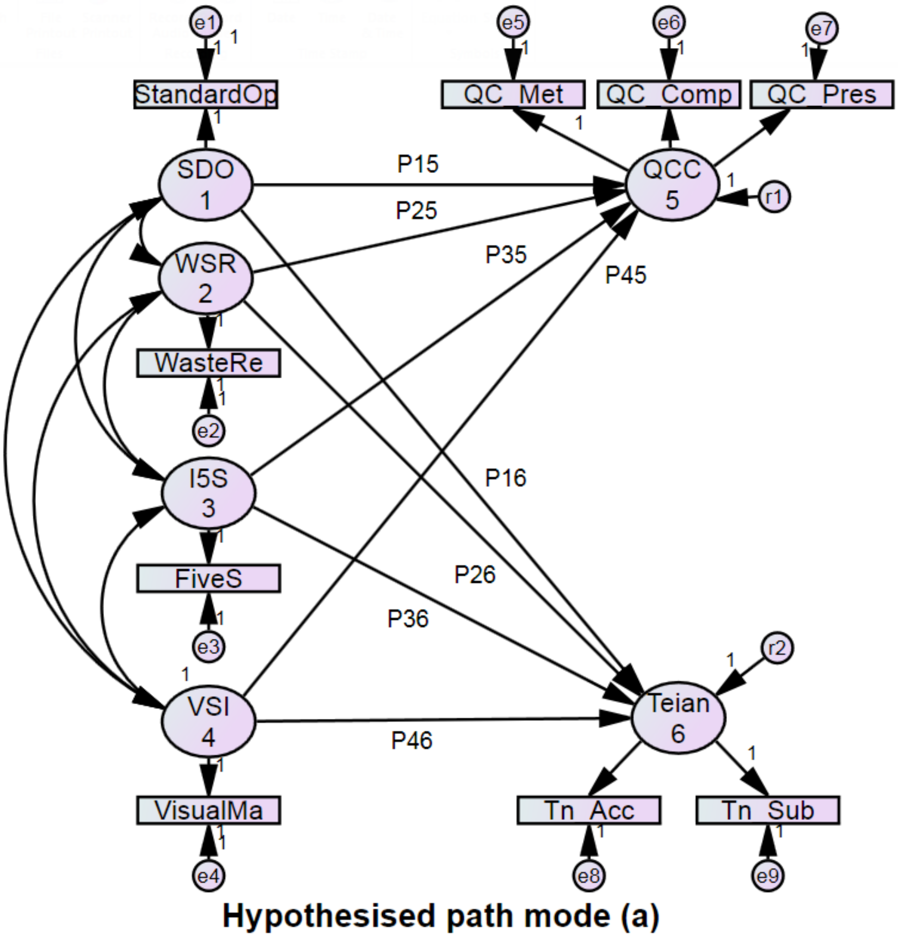


Figure 7.2 The hypothesised path model (a) based on the theoretical model (AMOS Graphics)

The variables in hypothesised path model (a) were developed and tested in the previous chapter and they are listed in the following Table 7.2.

Associated measurement scales		Latent variables in the PA model	Observed variables in the PA Model	Total
1	**Standard operations**	**SDO_1**	**StandardOp** (the sum of **SDO1- SDO4**)	1
2	**Waste removal**	**WSR_2**	**WasteRe** (the sum of **WSR1- WSR3**)	1
3	**5S practice**	**I5S _3**	**FiveS** (the sum of **I5S1- I5S15**)	1
4	**Visual management**	**VSI _4**	**VisualMa** (the sum of **VSI1- VSI4**)	1
5	**QCCs**	**QCC_5**	**QC_Met** (the product of **QC_Meet_Times** & **QC_Met_Length**), **QC_Comp** and **QC_Pres**	3
6	***Teians***	***Teian*_6**	**Tn_Sub** and **Tn_Acc**	2
	Total Latent Variables	***6***	***Total Observed Variables***	***9***

Table 7.2 The latent and observed variables in the hypothesised path model (a)

The model comprised four *latent variables* that represent shop floor management tools (**SDO_1**, **WSR_2**, **I5S_3** and **VSI_4**) and two *latent variables* that represent improvement implementation (**QCC_5** and ***Teian*_6**). Each of the *latent variables* was measured by their associated *observed variable(s)*. Also, the four shop floor management *latent variables* (**SDO_1**, **WSR_2**, **I5S_3** and **VSI_4**) were hypothesised *independent variables*. They were regressed onto their respective *dependent variables* (**QCC_5** and ***Teian*_6**). Each of the *dependent variables* was assigned a *residual error term* (**r1** and **r2**) and each of the *observed variables* was assigned a *measurement error* (**e1** to **e9**) respectively. Finally, the four shop floor *latent variables* (**SDO_1**, **WSR_2**, **I5S_3** and **VSI_4**) were shown to be intercorrelated.

7.1.2 Model identification for model (a)

After the model specification, it was crucial to identify the *degrees of freedom* prior to the estimation of the model (see Table 5.12 in Section 5.3.3). According to (Rigdon, 1994, p276), the model (a) was overidentified. As mentioned in Table 7.2, the model contained 9 observed variables, thus it had 45 (calculated by 9×10/2) observations (*distinct sample moments*). In addition, according to the AMOS Parameter Summary, the hypothesised model (a) had 28 unfixed parameters (*distinct parameters to be estimated*). As a consequence, the hypothesised path model had 17 (calculated by 45-28) *degrees of freedom* (*D.f*) (Table 7.3).

Number of distinct sample moments:	45
Number of distinct parameters to be estimated:	28
Degrees of freedom (45 - 28):	17

Table 7.3 Computation of degrees of freedom (Hypothesised path model (a), AMOS Output)

The statistical power (π) was assessed. According to McQuitty (2004) (see Table 5.14 in Section 5.3.3) the sample size obtained was adequate and the statistical power of the hypothesised path model (a) was π>0.70 (high), as *D.f.* of the model was 17 and the sample size was 371.

7.1.3 Model estimation for model (a)

Following model identification the model estimation procedure was selected. As mentioned in Section 5.3.3 (see Table 5.15), the ULS, WLS and ADF were discarded as the sample size was less than 1000. As the variables violated the normality assumption (as identified in Section 6.2) the ML method, rather than the GLS method, was adopted for the parameter estimations.

7.1.4 Model testing for model (a)

The ML method was applied to the model. As mentioned in Section 5.3.3, the three common testing indices: i) the parameter estimates with statistical significance level and standard errors; ii) the residuals; and iii) the model fit indices; were included to indicate the model fit.

Firstly, as shown in the following Table 7.4, only 5 paths had significant estimates (**P15**, **P26**, **P35**, **P36** and **P46**, *p≤0.05, or* '***' which *indicates p<0.001*). The remaining estimates were not statistically significant (**P16**, **P25** and **P45** with *p>0.05*). They indicated bad model fit (Wu, 2009).

	Label	Standardised Path Estimate	Path Estimate	S.E.	C.R.	P (*Sign.*)
QCC_5 <--- SDO_1	**P15**	**.245**	**.030**	**.010**	**3.027**	**.002**
Teian_6 <--- SDO_1	P16	.073	.077	.057	1.352	.176
QCC_5 <--- WSR_2	P25	.099	.015	.011	1.340	.180
Teian_6 <--- WSR_2	**P26**	**.130**	**.171**	**.069**	**2.467**	**.014**
QCC_5 <--- I5S_3	**P35**	**.279**	**.033**	**.009**	**3.493**	*******
Teian_6 <--- I5S_3	**P36**	**.447**	**.453**	**.053**	**8.540**	*******
QCC_5 <--- VSI_4	P45	.009	.001	.010	.118	.906
Teian_6 <--- VSI_4	**P46**	**.107**	**.121**	**.062**	**1.957**	**.050**

Table 7.4 The ML path estimates of the model (a), all significant and meaningful estimates are shown in bold

The Standardised Residual Covariance Matrix measures the fit of the hypothesised model (Wu, 2009). The Standardised Residual Covariance Matrix for this research is provided in Appendix F. It shows that there were 6 covariances (shown in bold) in the hypothesised model (a) that fell within the range of ±2.58. This was also an indication of bad model fit (Jöreskog, 1993).

Furthermore, the model fit indices were assessed. Some important fit indices (see Table 5.16 in Section 5.3.3) are listed in Table 7.5 for the hypothesised path model (a). These include Chi-square (χ^2), the goodness of fit index (GFI), comparative fit index (CFI), incremental fit index (IFI), normed fit index (NFI), root mean square error of approximation (RMSEA) and the standardised root means square residual (SRMR).

Model Fitness Statistics	Fitness Indices	Estimated Indices	Model Fit
Normed indices of fit			
Chi-square (χ^2)	*p > .05*	98.394, *D.f* .= 17 (p < 0.01)	No
GFI	> 0.9	**0.947**	**Yes**
AGFI	> 0.9	0.859	No
RMR	< 0.05	0.289	No
SRMR	≤ 0.05	0.077	No
RMSEA	≤ 0.05	0.114	No
ECVI	< saturated and independence model	No	No
Incremental indices of fit			
NFI	> 0.9	0.817	No
RFI	> 0.9	0.613	No
IFI	> 0.9	0.844	No
TLI	> 0.9	0.657	No
CFI	> 0.9	0.838	No
Parsimony-based indices of fit			
PCFI	> 0.5	0.396	No
PNFI	> 0.5	0.386	No
CN	> 200	126	No
NC (CMIN/DF)	1 < NC < 3	5.788	No

Table 7.5 The selected common model fit indices for the hypothesised path model (a)
(Note: good model fit indices shown in bold)

From Table 7.5 the model fit indices show a relatively poor model fit, since only one of the common indices (GFI) indicates good model fit. Other important indices (e.g., NFI, RFI, RMSEA etc.) were all below the usual acceptable level of fit. Accordingly, this particular set of model fit indices indicated that the data-to-model fit was only approaching a reasonable level. This indicated that modifications were necessary to improve fit.

7.1.5 Model modification for model (a)

Next, a theory-driven (vs. data-driven) model modification was performed (see Section 5.3.3). Figure 7.3 illustrates the modified path model (a).

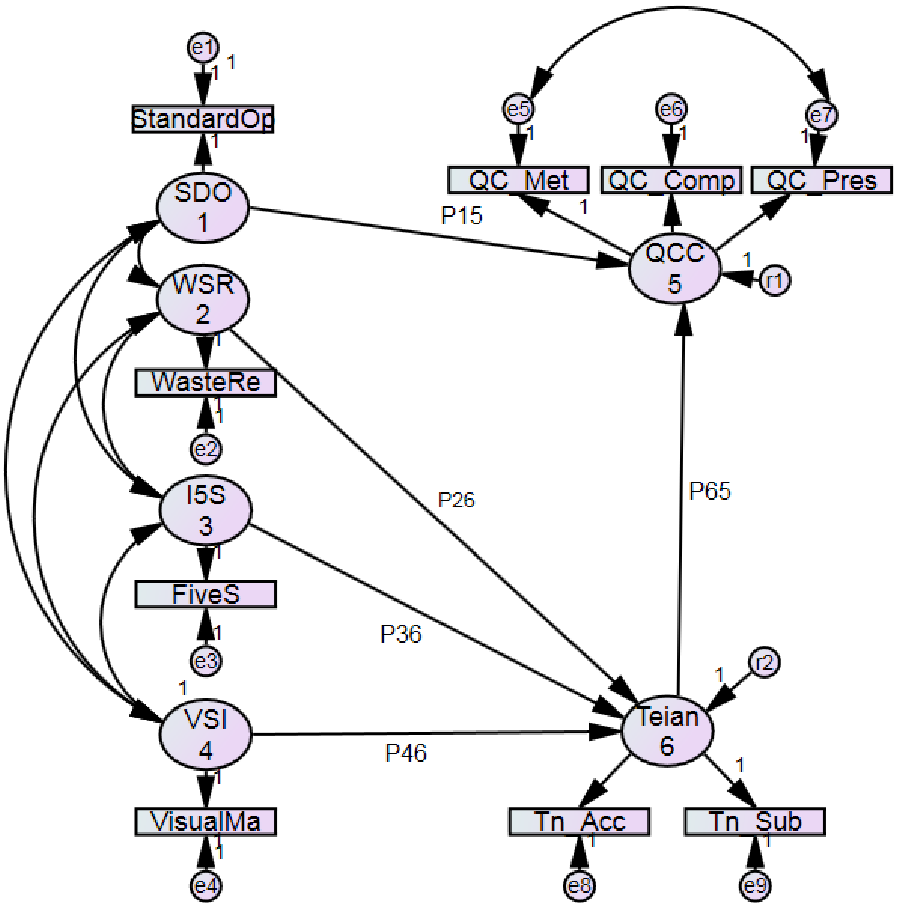


Figure 7.3 The modified path model (a) for the theoretical model (AMOS Graphics)

Initially, the insignificant parameters (paths) were removed to form a better fitting model (Byrne, 2010). Thus, as shown in Figure 7.3, thee three insignificant paths (**P16, P25** and **P45**) were deleted to increase the overall fit of the model. In addition, **P35** was removed, as its estimate was changed; it had become an insignificant path in the modified model. *Secondly*, new parameters (paths) could have been included if they had reached an appropriate significant level ($p<0.05$) and were supported by underlying theories. In addition, the existing fixed parameters could have been freely estimated (e.g., the covariances of measurement error) if they made practical sense. In this stage, a new path (**P65,** *Teians* have a positive effect on QCCs) and a covariance of measurement error (between **e5** and **e7,** as the two QCC observed variables could have a shared measurement error) were included. *Thirdly*, the Standardised Residual Covariance Matrix was assessed. In the modified model (Figure 7.3), all variables in the Standardised Residual Covariance Matrix were within the recommended range of ±2.58 (Appendix F).

After these modifications, the modified path model (Figure 7.3) had 9 observed variables, and thus, it had 45 (calculated by 9×10/2) observations (*distinct sample moments*). According to the AMOS Parameter Summary, the modified model (a) had 26 unfixed parameters (*distinct parameters to be estimated*). As a consequence, the modified path model was overidentified with 19 (45-26) *degrees of freedom* (Table 7.6).

Number of distinct sample moments:	45
Number of distinct parameters to be estimated:	26
Degrees of freedom (45 - 26):	19

Table 7.6 Computation of degrees of freedom (Modified path model, AMOS Output)

The path estimates from the ML method for the modified model is shown in Table 7.7. All of the 5 direct paths were statistical significant ($p<0.05$).

Path				Label	Hypothesised model (a)		Modified model (a)			
					St. P. Est.	Estimate	St. P. Est.	P. Estimate	S.E.	C.R.
QCC_5	<---	SDO_1		P15	.245	.030**	.196	.032***	.010	3.39
*Teian*_6	<---	SDO_1	(Removed)	P16	.073	.077	-	-	-	-
QCC_5	<---	WSR_2	(Removed)	P25	.099	.015	-	-	-	-
*Teian*_6	<---	WSR_2		P26	.130	.171*	.102	.139*	.070	1.993
QCC_5	<---	I5S_3	(Removed)	P35	.279	.033***	-	-	-	-
*Teian*_6	<---	I5S_3		P36	.447	.453***	.431	.453***	.053	8.503
QCC_5	<---	VSI_4	(Removed)	P45	.009	.001	-	-	-	-
*Teian*_6	<---	VSI_4		P46	.107	.121*	.135	.158**	.059	2.660
QCC_5	<---	*Teian*_6	(Added)	P65	-	-	.529	.080***	.011	7.105

(Note: * *p<0.05, ** p<0.01, and *** P<0.001*)

Table 7.7 The comparisons for PA between the hypothesised model (a) and the modified model (a)

The fit of the modified model (a) was revealed by its model fit indices. From Table 7.8, the modified model indices showed good model fit. In particular, the χ^2 statistic was equal to 36.873 (p=0.008), with 19 degrees of freedom. However, due to the sample size (n=371) and the sensitivity of the ML method, the CMIN/DF (χ^2 / Degrees of freedom ratio) had a value of 1.941 (within the range of 1 and 3) which indicated an acceptable model fit (see Byrne, 2010, p76). In addition, many other indices had also improved to above the usual acceptable level of fit. As such, these particular set of model fit indices indicated that the data-to-model fit was at a satisfactory level. Thus, this was deemed to be the final path model for theoretical model (a).

Model Fitness Statistics	Indices for Hypothesised Model	Indices for Modified Model	Model Fit
Normed indices of fit			
Chi-square (χ^2) (p > .05)	98.394, *D.f* .= 17 (p < 0.01)	36.873, *d.f* .= 19 (p =0.008)	No
GFI (> 0.9)	**0.947**	**0.977**	**Yes**
AGFI (> 0.9)	0.859	**0.946**	**Yes**
RMR (< 0.05)	0.289	0.238	No
SRMR (≤ 0.05)	0.077	**0.0351**	**Yes**
RMSEA (≤0.05)	0.114	**0.05**	**Yes**
ECVI (< saturated and independence model)	No	**Yes**	**Yes**
Incremental indices of fit			
NFI (> 0.9)	0.817	**0.931**	**Yes**
RFI (> 0.9)	0.613	0.870	No
IFI (> 0.9)	0.844	**0.966**	**Yes**
TLI (> 0.9)	0.657	**0.933**	**Yes**
CFI (> 0.9)	0.838	**0.964**	**Yes**
Parsimony-based indices of fit			
PCFI (> 0.5)	0.396	**0.509**	**Yes**
PNFI (> 0.5)	0.386	0.492	No
CN (>200)	126	**364**	**Yes**
CMIN/DF(1 < CMIN/DF < 3)	5.788	**1.941**	**Yes**

Table 7.8 The comparisons for the model fit indices between the hypothesised model and the modified model (Note: good model fit indices shown in bold)

7.2 Hypothesised Model (b) for Testing H2 and H3

The hypothesised model (b) (Figure 7.4) was developed to investigate the relationship between the two improvement practices (**H2**) and the outcomes (**H3**). This model was defined in Section 4.3.2 (Figure 4.10).

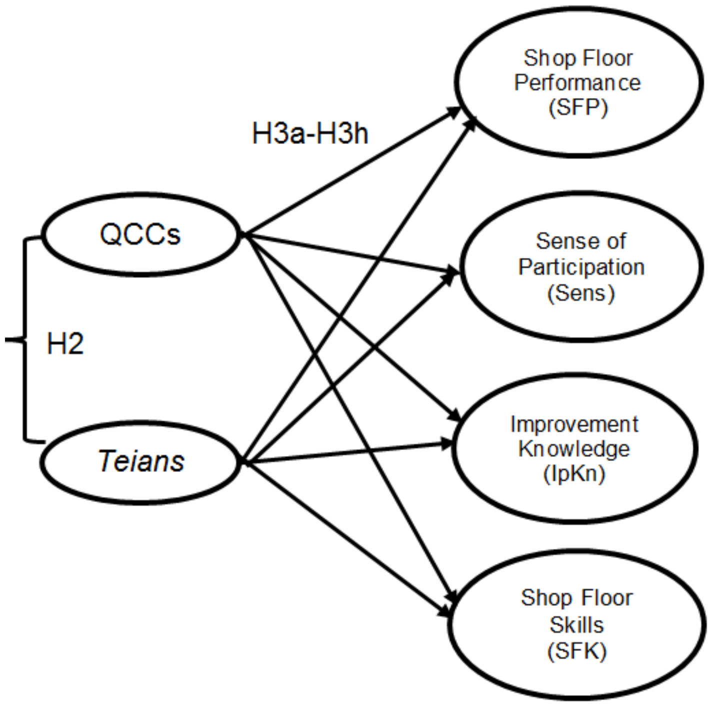


Figure 7.4 The hypothesised model (b) for H2 and H3

H3 was expanded to take into account the relationship between the two improvement practices and the four identified improvement outcomes measures. This resulted in the following **H2** and eight sub-hypotheses for **H3** (Table 7.1).

H2. The two improvement practices are mutually supportive
H3. The two improvement practices have positive effects on the long-term outcomes
H3a. QCCs have positive effects on *shop floor performance.* **H3b.** QCCs have positive effects on the *sense of participation*. **H3c.** QCCs have positive effects on *improvement knowledge*. **H3d.** QCCs have positive effects on *shop floor skills*.
H3e. *Teians* have positive effects *shop floor performance.* **H3f.** *Teians* have positive effects on the *sense of participation*. **H3g.** *Teians* have positive effects on *improvement knowledge*. **H3h.** *Teians* have positive effects on *shop floor skills*.

Table 7.9 the hypotheses for H2 and H3

7.2.1 Model specification for model (b)

A full PA model was created by using the AMOS Graphics and used SEM's path symbol notation (see Figure 5.9 in Section 5.3.1). The hypothesised path model (b) consisted of 6 latent variables and the associated 22 inferred observed variables. Figure 7.5 depicts the hypothesised path model (b).

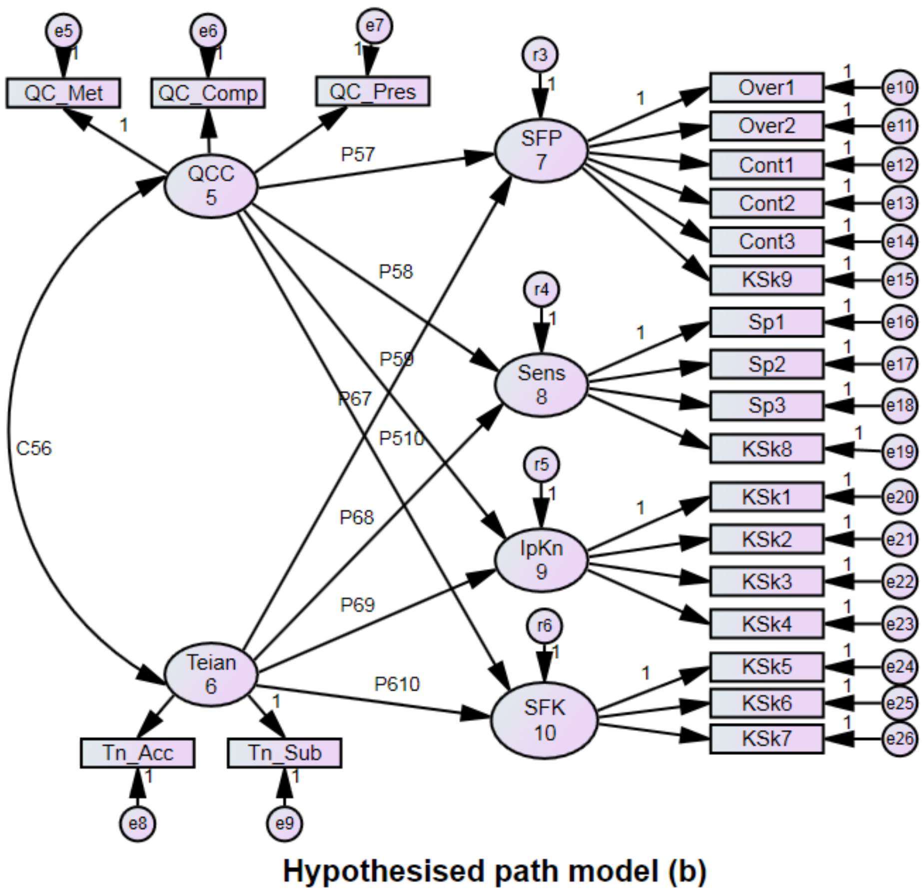


Figure 7.5 The hypothesised path model (b) based on the theoretical model (AMOS Graphics)

The variables in hypothesised path model (b) were developed and tested in the previous chapter and they are listed in Table 7.10.

Associated measurement scales		Latent variables in the PA model	Observed variables in the PA Model	total
1	**QCCs**	**QCC_5**	**QC_Met** (the product of **QC_Meet_Times** & **QC_Met_Length**), **QC_Comp** and **QC_Pres**	3
2	***Teians***	***Teian*_6**	**Tn_Sub** and **Tn_Acc 2**	2
3	**Fulfilment of improvement implementation**	**Fulfil_7**	**Over1**, **Over2**, **Cont1**, **Cont2**, **Cont3** and **KSk9**	6
4	**Sense of participation**	**Sens_8**	**Sp1**, **Sp2**, **Sp3** and **KSk8**	4
5	**Improvement Knowledge**	**IpKnow_9**	**KSk1-KSk4**	4
6	**Shop floor Skills**	**ShopSkill_10**	**KSK5-KSk7**	3
	Total Latent Variables	***6***	***Total Observed Variables***	***22***

Table 7.10 The latent and observed variables in the hypothesised path model (b)

This model comprised two *latent variables* to represent improvement implementation (**QCC_5** and ***Teian*_6**) and *four latent variables* to represent improvement outcomes (**SFP_7**, **Sens_8**, **IpKn_9**, and **SFK_10**). Each of the *latent variables* was measured by their associated *observed variable(s)*. Also, the two improvement practices *latent variables* (**QCC_5** and ***Teian*_6**) were the hypothesised *independent variables*. They were regressed onto their respective *dependent variables* (**SFP_7**, **Sens_8**, **IpKn_9**, and **SFK_10**). Each of the *depended variables* had an assigned *residual error term* (**r3** to **r6**) and each of the *observed variables* had a *measurement error* (**e5** to **e26**). Finally, the two improvement practices *latent variables* (**QCC_5** and **Teian_6**) were shown to be intercorrelated.

7.2.2 Model identification for model (b)

After the model specification, it was crucial to identify the *degrees of freedom* prior to the estimation of the model (see Table 5.12 in Section 5.3.3). Table 7.10 shows that the model contained 22 observed variables and had 253 (calculated by 22×23/2) observations (*distinct sample moments*). According to the AMOS Parameter Summary, the hypothesised model (b) had 53 unfixed parameters (*distinct parameters to be estimated*). As a consequence, the modified path model was overidentified with 200 (253-53) *degrees of freedom* (Table 7.11).

Number of distinct sample moments:	253
Number of distinct parameters to be estimated:	53
Degrees of freedom (253 - 53):	200

Table 7.11 Computation of degrees of freedom (Hypothesised path model (b), AMOS Output)

Furthermore, the statistical power (π) was assessed. According to McQuitty (2004) (see Table 5.14 in Section 5.3.3), the sample size was adequate and the statistical power of the hypothesised path model (a) was π>0.90 (very high), as *D.f.* of the model was 200 and the sample size was 371.

7.2.3 Model estimation for model (b)

Models (a) and (b) both had a sample size of 371. They both violated the normality assumption. Based on the previous analysis the ULS, WLS, ADF and GLS methods were discarded. The ML method was employed to test the model (b).

7.2.4 Model testing for model (b)

Table 7.12 shows the viability of the parameter estimates. Only 7 (**P57**, **P58**, **P59**, **P510**, **P69**, **P610** and **C56**) of them were significant (*p<0.05, or* '*******' which *indicates p<0.001*). The remaining (**P67** and **P68**) were insignificant estimates. This indicated bad model fit (Wu, 2009).

	Label	Standardised Path Estimate	Path Estimate	S.E.	C.R.	P (*Sign.*)
SFP_7 <--- QCC_5	**P57**	**.891**	**1.765**	**.428**	**4.129**	*******
Sens_8 <--- QCC_5	**P58**	**.916**	**1.669**	**.410**	**4.073**	*******
IpKn_9 <--- QCC_5	**P59**	**1.573**	**3.285**	**.752**	**4.366**	*******
SFK_10 <--- QCC_5	**P510**	**1.095**	**2.680**	**.623**	**4.299**	*******
SFP_7 <--- Teian_6	P67	-.270	-.053	.037	-1.413	.158
Sens_8 <--- Teian_6	P68	-.398	-.071	.036	-1.956	.051
IpKn_9 <--- Teian_6	**P69**	**-1.119**	**-.229**	**.069**	**-3.308**	*******
SFK_10 <--- Teian_6	**P610**	**-.781**	**-.188**	**.058**	**-3.230**	**.001**
Teian_6 <--> QCC5	**C56**	**.852**	**1.166**	**.173**	**6.735**	*******

Table 7.12 The ML path estimates of the model (b), all significant and meaningful estimates are shown in bold

The Standardised Residual Covariance Matrix was inspected to identify if any standardised residuals (fitting errors) were outside the required range of ±2.58 (Rong, 2009; Wu, 2009). Standardised residuals outside this range would indicate the values are not well accounted for by the model; thus there may be misspecifications of relationships between different parameters (paths/variables) (Schumacker and Lomax, 2004). The Standardised Residual Covariance Matrix for hypothesised model (b) is provided in Appendix G. There were 11 values which were observed over ±2.58 (including 3 values over ±3). This indicated possible problems with model fit.

Next, the model fit for hypothesised model (b) was revealed by the model fit indices. The fit indices denoted in the Table 7.13 showed a poor model fit. Although some of the common indices (i.e., GFI, IFI, CFI, PCFI, PNFI and CN) indicated good model fit, many other statistics were below the usual acceptable level (Table 7.13). Accordingly, these particular set of model fit indices would indicate that the data-to-model fit was only approaching a reasonable level. Some model modifications were required to improve fit.

Model Fitness Statistics	Fitness Indices	Estimated Indices	Model Fit
Normed indices of fit			
Chi-square (χ^2)	*p > .05*	391.816 *d.f.* = 200 (p < 0.01)	No
GFI	> 0.9	**0.910**	**Yes**
AGFI	> 0.9	0.887	No
RMR	< 0.05	0.091	No
SRMR	≤ 0.05	0.0655	No
RMSEA	≤ 0.05	0.051	No
ECVI	< saturated and independence model	**Yes**	**Yes**
Incremental indices of fit			
NFI	> 0.9	0.830	No
RFI	> 0.9	0.803	No
IFI	> 0.9	**0.909**	**Yes**
TLI	> 0.9	0.883	No
CFI	> 0.9	**0.907**	**Yes**
Parsimony-based indices of fit			
PCFI	> 0.5	**0.785**	**Yes**
PNFI	> 0.5	**0.718**	**Yes**
CN	> 200	**221**	**Yes**
NC (CMIN/DF)	1 < NC < 3	**1.959**	**Yes**

Table 7.13 The selected common model fit indices for the hypothesised path model (b)
(Note: good model fit indices shown in bold)

7.2.5 Model modification for model (b)

Next, a theory-driven (vs. data-driven) model modification was applied to the hypothesised path model (b) to seek a better fit (Figure 7.6). *Initially*, two paths (**P67** and **P68**) with insignificant estimates were excluded from the model. *Secondly*, two observed variables were removed (**KSk8** and **KSk9**), as their associated residuals (fitting errors) were over ±2.58 in the Standardised Residual Covariance Matrix. They indicated that the associated observed variables were not well accounted for by the latent variables in the model (Jöreskog, 1993; Rong, 2009). In the modified model, all variables in the Standardised Residual Covariance Matrix were within the recommended range of ±2.58 (Appendix G). *Thirdly*, a new path (**P78**) was included since its estimate reached the significant level (*p<0.05*) and it is supported by substantive theories.

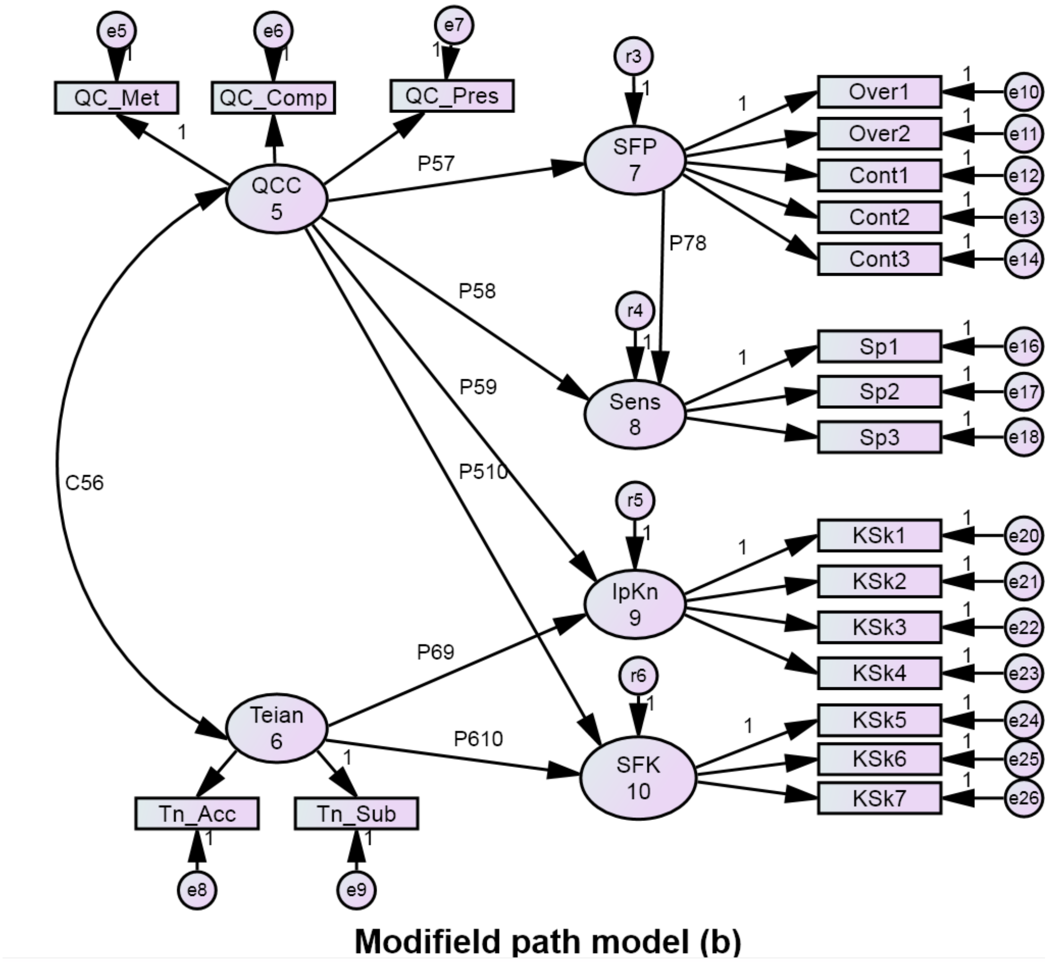


Figure 7.6 The modified path model for the theoretical model (b) (AMOS Graphics)

After these modifications, the modified path model (b) (Figure 7.6) had 20 observed variables (2 observed variables were removed from the initial model), and thus, it had 210 (calculated by 20(21)/2) *distinct sample moments* (Table 7.14). In addition, according to the AMOS Parameter Summary, the modified model had 48 unfixed parameters (*distinct parameters to be estimated*). As a consequence, the modified path model was overidentified with 162 (210-48) *degrees of freedom* (Table 7.14).

Number of distinct sample moments:	210
Number of distinct parameters to be estimated:	48
Degrees of freedom (210 - 48):	162

Table 7.14 Computation of degrees of freedom (Modified path model (b), AMOS Output)

The path estimates from the ML method for the modified model is shown in Table 7.15. All of the 8 direct paths from the modified model (b) had statistically significant (*$p<0.05$*) estimates compared to the hypothesised model.

Path				Label	Hypothesised model		Modified model			
					St. P. Est.	P. Estimate	St. P. Est.	P. Estimate	S.E.	C.R.
SFP_7	<---	QCC_5		P57	.891	1.765***	.549	1.190***	.202	5.889
Sens_8	<---	QCC_5		P58	.916	1.669***	.164	.316*	.150	2.103
IpKn_9	<---	QCC_5		P59	1.573	3.285***	1.783	3.846***	.672	5.721
SFK_10	<---	QCC_5		P510	1.095	2.680***	.999	2.547***	.508	5.012
SFP_7	<---	Teian_6	(Removed)	P67	-.270	-.053	-	-	-	-
Sens_8	<---	Teian_6	(Removed)	P68	-.398	-.071	-	-	-	-
IpKn_9	<---	Teian_6		P69	-1.119	-.229***	-1.271	-.255***	.053	-4.822
SFK_10	<---	Teian_6		P610	-.781	-.188**	-.678	-161***	.042	-3.856
Teian_6	<-->	QCC5		C56	.852	1.166***	.837	1.106***	.166	6.646
Sens_8	<---	SFP_7	(Added)	P78	-	-	.542	.481***	.084	5.710

(Note: * p<0.05, ** p<0.01, and *** P<0.001)

Table 7.15: The comparisons for PA between the hypothesised model (b) and the modified model (b)

Model Fitness Statistics	Indices for Hypothesised Model	Indices for Modified Model	Model Fit
Normed indices of fit			
Chi-square (χ^2) ($p > .05$)	391.816 *d.f* .= 200 (p < 0.01)	249.198, *d.f* .= 162 (p<0.01)	No
GFI (> 0.9)	**0.910**	**0.939**	**Yes**
AGFI (> 0.9)	0.887	**0.921**	**Yes**
RMR (< 0.05)	0.091	0.076	No
SRMR (<= 0.05)	0.0655	**0.0486**	**Yes**
RMSEA (< 0.05)	0.051	**0.038**	**Yes**
ECVI (< saturated and independence model)	**Yes**	**Yes**	**Yes**
Incremental indices of fit			
NFI (> 0.9)	0.830	0.877	No
RFI (> 0.9)	0.803	0.857	No
IFI (> 0.9)	**0.909**	**0.954**	**Yes**
TLI (> 0.9)	0.883	**0.945**	**Yes**
CFI (> 0.9)	**0.907**	**0.953**	**Yes**
Parsimony-based indices of fit			
PCFI (> 0.5)	**0.785**	**0.818**	**Yes**
PNFI (> 0.5)	**0.718**	**0.752**	**Yes**
CN (>200)	**221**	**288**	**Yes**
CMIN/DF(1 < CMIN/DF < 3)	**1.959**	**1.529**	**Yes**

Table 7.16: The comparisons for the model fit indices between the hypothesised model and the modified model (Note: good model fit indices shown in bold)

The fit of the modified model was also revealed by its model fit indices. From the table (Table 7.16), the modified model indices showed a fairly good model fit. In particular, the χ^2 (Chi-square) statistic was equal to 249.198 (p=0.162), with 162 degrees of freedom. In addition, due to the sample size (over 300) and the sensitivity of the ML method, the CMIN/DF (χ^2 / Degrees of freedom ratio) had the value of 1.529 (within the range of 1 and 3 that indicated good model fit). As such, the χ^2 statistic for this model indicated a good model fit (see Byrne, 2010, p76). Furthermore, all of the other indices had also improved. More importantly, most of them were above the usual acceptable level of fit, and only three of the indices (RMR, NFI and RFI) indicated poor fit. Therefore, these particular set of model fit indices indicated that the data-to-model fit was satisfactory. Thus this was deemed to be the final path model for the theoretical model.

7.3 The Reliability of the Model Fit Indices and Model Estimates

Following model testing and modification, the best data-to-model fits for the two models had been identified. However, the model fit indices and model estimates were subjected to a reliability check before they were employed for hypotheses testing.

7.3.1 The assessment of multivariate normality

An inspection to test for the multivariate normality of the sample data was required. Loehlin (2004) and Byrne (2010), identified two critical assumptions for path analysis: i) to have a multivariate normal distribution; and ii) a continuous scale.

Two indicators in AMOS Assessment of Normality can be used to identify multivariate normality of the data: the first indicator is the univariate skewness/kurtosis and its associated Critical Ratio (C.R.). They can be used to assess the univariate normal distribution of the data (Arbuckle, 2007). The absolute value of the C.R. should exceed 2 to indicate statistically significant degrees of univariate nonormality (Kline, 2005; Wu, 2009). Furthermore, as West (1995) and Tabachnick and Fidell (2007) explained, the univariate normal distribution of the observed variables may not guarantee the multivariate normal distribution. Accordingly, the multivariate kurtosis ($ß_2$) is also needed, as the second indicator, to examine the multivariate distribution of the data (Arbuckle, 2006). The $ß_2$ is the exceptional determinant in SEM analyses (DeCarlo, 1997). In general, a value of 3 is an indication of $ß_2$ in a normal distribution, but in AMOS, the $ß_2$ is rescaled to make zero an indicator of normal distribution (Kline, 2005; Byrne, 2010). As such, the value of 7 should be used as a guide to show the indicative of early departure from normality (Byrne, 2010). Furthermore, the C.R. for the $ß_2$ is another important index for observing nonnormal distribution of the data (Arbuckle, 2006). Bentler (2005) suggested, the value of the C.R. for the $ß_2$ should be adopted and the value of less than 5 can indicate a multivariate normally distributed data set.

The data set could contain non-continuous data samples (i.e., Likert-scale). Therefore, it was necessary to perform the multivariate normality check.

Initially, the obtained data for the modified model (a) was inspected and the result is shown in Table 7.17. As the AMOS Normality Output shows, the obtained data set for the model (a) violated the univariate normality assumption, but the violation was within the acceptable range for the ML method. The univariate skewness values ranged from -0.643 to 0.881 and its C.R. values ranged from -5.056 to 6.925 (does not fall within the range of ±2). The univariate kurtosis values ranged from -1.131 to 1.446 and its C.R. values ranged from -4.448 to 5.687 (also it did not fall within the range of ±2). However, based upon the study by Wu (2009, p273), if the univariate skewness values did not exceed 8, and the univariate kurtosis values did not exceed 3, the data set may still have been suitable for the ML estimation. From a multivariate perspective, the $ß_2$ (multivariate kurtosis) in the data set of the modified model (a) was found to be 3.394 (less than the threshold value of 7) and the C.R. for the $ß_2$ was 2.323 (also less than the threshold value of 5), and they were all within the threshold limits. In this sense, this sample data set of the modified model (a) was considered to fall within the acceptable range of the multivariate normality for ML estimation, and the results generated above should be accurate model estimates.

Variable	min	max	skew	c.r.	kurtosis	c.r.
QC_Pres___6	.000	4.000	**.881**	**6.925**	.977	3.840
QC_Met	1.000	4.000	.122	.959	-.916	-3.601
WasteRe	3.000	21.000	.280	2.202	.164	.643
QC_Comp___4	.000	4.000	.322	2.531	-.499	-1.962
Tn_Acc___11	.000	9.000	.150	1.178	**-1.131**	**-4.448**
Tn_Sub___10	.000	18.000	.112	.878	-.741	-2.913
FiveS	7.000	35.000	**-.643**	**-5.056**	**1.446**	**5.687**
VisualMa	7.000	26.000	-.382	-3.001	-.165	-.649
StandardOp	8.000	27.000	-.518	-4.077	.138	.542
Multivariate					3.394	2.323

Table 7.17: Assessment of normality for the modified model (a) (AMOS Output)

In addition, the data obtained for the modified model (b) was also inspected in a similar way (Table 7.18). However, the AMOS Normality Output shows that the data set was lumpy (did not meet both the univariate and multivariate normality assumption), as the univariate skewness values ranged from -1.033 to 0.881 and its C.R. values ranged from -8.123 to 6.925 (did not fall within the range of ±2). The univariate kurtosis values ranged from -1.131 to 1.063 and its C.R. values ranged from -4.448 to 4.180 (did not fall within the range of ±2 either). Additionally, from a multivariate perspective, the $ß_2$ (multivariate kurtosis) was found to be 34.376 (greater than the threshold value of 7) and the C.R. for the $ß_2$ was 11.160 (also greater than the threshold value of 5). As such, the sample data set of the modified model (b) violated both univariate and multivariate assumptions. Hence, the ML method could generate inaccurate model estimates. In such circumstances, the bootstrap analysis for path estimations is recommended to estimate bias (Schumacker and Lomax, 2004) .

Variable	min	max	skew	c.r.	kurtosis	c.r.
QC_Pres___6	.000	4.000	**.881**	**6.925**	.977	3.840
QC_Met	1.000	4.000	.122	.959	-.916	-3.601
KnSk_7__43	1.000	7.000	-.562	-4.420	-.061	-.239
KnSk_6__42	2.000	7.000	-.525	-4.129	-.299	-1.177
KnSk_5__41	2.000	7.000	-.396	-3.112	-.458	-1.803
KnSk_4__40	1.000	7.000	-.464	-3.647	-.072	-.282
KnSk_3__39	2.000	7.000	-.311	-2.444	-.476	-1.873
KnSk_2__38	2.000	7.000	-.663	-5.213	.497	1.954
KnSk_1__37	2.000	7.000	-.559	-4.398	-.148	-.584
Sp_3___36	2.000	7.000	-.846	-6.649	.381	1.498
Sp_2___35	1.000	7.000	-.961	-7.557	.957	3.761
Sp_1___34	2.000	7.000	-.537	-4.219	-.072	-.284
Contribution_3___33	1.000	7.000	**-1.033**	**-8.123**	**1.063**	**4.180**
Contribution_2___32	1.000	7.000	-.563	-4.423	-.505	-1.985
Contribution_1___31	1.000	7.000	-.821	-6.452	.393	1.546
Overall_2___30	2.000	7.000	-.644	-5.064	.048	.190
Overall_1___29	1.000	7.000	-.925	-7.272	.695	2.733
QC_Comp___4	.000	4.000	.322	2.531	-.499	-1.962
Tn_Acc___11	.000	9.000	.150	1.178	**-1.131**	**-4.448**
Tn_Sub___10	.000	18.000	.112	.878	-.741	-2.913
Multivariate					34.376	11.160

Table 7.18: Assessment of normality for the modified model (b) (AMOS Output)

7.3.2 The bootstrapping as an aid to assess the model fit for model (b)

In order to increase the degree of accuracy of the modified model (b), a 'bootstrap' analysis in AMOS was employed to determine the bias in the path estimations (West *et al.*, 1995; Loehlin, 2004, p. p60). The 'bootstrap' approach was initialised by Efron (1979; 1982) and supported by many subsequent studies (and Loehlin, 2004, p82; as listed by Byrne, 2010, p330). The 'bootstrap' analysis is a technique to maximise the accuracy of the estimation by creating multiple repeated samples from the original data set (Loehlin, 2004, p. p60) and examining each of the repeated samples (Byrne, 2010). It could determine the amount of bias (Schumacker and Lomax, 2004), evaluate stability (Loehlin, 2004), and generate less biased and more precise results compared to the standard estimation methods (e.g., the standard ML or GLS methods) if the sample size is over 200 (Lunneborg, 1987; Nevitt and Hancock, 2001; Kline, 2005). More essentially, the bootstrap analysis in AMOS also provides the assessment of the overall model fit indices and the recommended corrections for path analysis (Kline, 2005). Less biased model fit indices and estimates from the AMOS bootstrap analysis could be employed to determine the reliability/viability of the regular ML model fit indices and could validate the stability of the standard ML path analysis.

In the current study, *first*, the Bollen-Stine bootstrap (a random bootstrap sample size set to 2000) as recommended by Nevitt and Hancock (2001) was used to obtain a bootstrap *p*-value to assess the overall model fit; and *second*, the ML bootstrap analysis was applied to validate and compare each of the path estimates and their associated standard error.

Iterations	Method 0	Method 1	Method 2
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	3	0
8	0	22	0
9	0	51	0
10	0	140	0
11	0	257	0
12	0	266	0
13	0	244	0
14	0	247	0
15	0	184	0
16	0	160	0
17	0	114	0
18	0	91	0
19	0	221	0
Total	0	2000	0

0 bootstrap samples were unused because of a singular covariance matrix.
0 bootstrap samples were unused because a solution was not found.
2000 usable bootstrap samples were obtained.

Table 7.19: Summary of Bootstrap Iterations (AMOS Output)

AMOS provides information for bootstrap analysis. Table 7.19 shows the summary of the bootstrap iterations for modified model (b). It contains four columns to illustrate the minimisation history and the three minimisation methods. The three method columns are ordered from left to right in terms of their speed and reliability. In addition, each column also lists the number of samples required for this method to arrive at a successful solution. According to the AMOS Help System, the **Method 0** is the slowest minimisation method and is currently not available in AMOS, and thus, this column always contains zero values for all rows. By contrast, the **Method 1** is generally a faster and more reliable algorithm, and hence, AMOS would first perform minimisation using **Method 1** followed by **Method 2**. The **Method 2** represents a slower (than the Method 1) but the most reliable minimisation method. However, this is used only when the **Method 1** fails to produce a particular bootstrap sample.

In reviewing Table 7.19, the information shows that **Method 1** was completed successfully in its task of bootstrapping 2000 usable samples and none was found to be unusable. As such, the **Method 2** was not used and the column contains zeroes only. Furthermore, the different numbers in the **Method 1** column reveals the numbers of bootstrap samples that have reached a minimum in the associated iterations (a successful solution found).

The Table 7.20 shows the Bollen-Stine bootstrap *p*-value which was used to assess the overall model fit. As the table shows, "the model fitted better than expected in 1994 bootstrap samples" of the 2000 repeated bootstrap samples. As such, the model "fitted worse than expected or failed in (only) 6 (2000-1994) bootstrap samples", or $p=0.003$ (6/2000), which was the *p*-value for the overall model fit. Using the conventional significance level of 0.05, it was concluded that the modified model fitted the data well (The University of Texas at Austin, 2011). As such, the overall model fit indices (as advised in Table 7.16) were accepted.

The model fit better in 1994 bootstrap samples. It fit about equally well in 0 bootstrap samples. It fit worse or failed to fit in 6 bootstrap samples. Testing the null hypothesis that the model is correct, Bollen-Stine bootstrap p = .003

Table 7.20: The significance level of the Bollen-Stine Bootstrap for the modified model (AMOS Output)

7.3.3 The bootstrapping as an aid to assess the path estimates for model (b)

After assessing the overall model fit, the path estimates and their associated standard errors were assessed by using the ML bootstrap method. In this analysis, the bootstrap sample size was set to be 2000 following the recommendation of Nevitt and Hancock (2001).

The unstandardised bootstrap estimates are listed in the Table 7.21. In reviewing the table, all of the bias values for path estimates were small (less than 0.02), and the small bias values indicated that discrepancies between the ML estimates and the bootstrap estimates were small. Furthermore, from a further inspection of the output, the critical ratios (C.R., the last column on the right of Table 7.21) for the bootstrap samples were calculated (dividing the mean of bootstrap estimates by their S.E.). The C.R. column showed that, all of the paths had statistically significant bootstrap C.R. values at a probability level of 0.05 (the C.R. values fell outside the threshold value of ±1.96). As such, the above path estimates were acceptable within the reliable range.

Path	Path estimates (unstandardised)			Bootstrap estimates (unstandardised)			
	Estimates	S.E.	C.R.	Estimates (Mean)	Estimates bias (Mean)	S.E.	C.R.
P57	1.190	.202	5.889	1.205	.005	.230	5.257
P58	.316	.150	2.103	.313	.004	.146	2.144
P59	3.846	.672	5.721	3.982	.017	.746	5.629
P510	2.547	.508	5.012	2.656	.015	.664	3.867
P69	-.255	.053	-4.822	-.266	.002	.069	-3.826
P610	-161	.042	-3.856	-.170	.001	.059	-2.864
C56	1.106	.166	6.646	1.102	.004	.165	6.666
P78	.481	.084	5.710	.480	.002	.100	4.840

Table 7.21: the comparison for the ML estimates and bootstrap estimates (AMOS Output)

Next, the confidence intervals of the bootstrap samples were reviewed (Efron, 1979; Mooney and Duval, 1993, pp., p50). Table 7.22 shows that, at the 95% confidence intervals (Efron and Tibshirani, 1993), all bootstrap paths estimates did not include zero. They indicate that all bootstrap paths were statistically significant (note for **P58**, p=0.056) and no paths needed to be removed (see Byrne, 2010, p351). In this respect, the bootstrap samples provided further support to the above results that all paths could be retained in the modified model for further analysis.

Path	Bias-corrected estimates			
	Estimate	Lower	Upper	*P*
P57	1.190	.876	1.603	.000
P58	.316	.043	.510	.056
P59	3.846	2.902	5.242	.001
P510	2.547	1.720	3.845	.001
P69	-.255	-.391	-.172	.001
P610	-161	-.278	-.089	.001
C56	1.106	.840	1.393	.000
P78	.481	.326	.642	.000

Table 7.22: The 95% confidence interval bias-corrected estimates (AMOS Output, unstandardised estimates)

7.4 The Path Estimates to Test the Research Hypotheses.

As stated above, the data-to-model fit of the two modified models was at a satisfactory level. The overall convergence was significant, and both of their path estimates and model fit indices were reliable.

7.4.1 The overall ML estimate results for model (a)

The modified model (a) was a recursive model (a model that specifies the causal direction in one direction only) (Byrne, 2010, p7). The model showed the relationships between the four building block shop floor management tools and the two improvement practices. Figure 7.7 shows the modified model (a) and its standardised paths estimates.

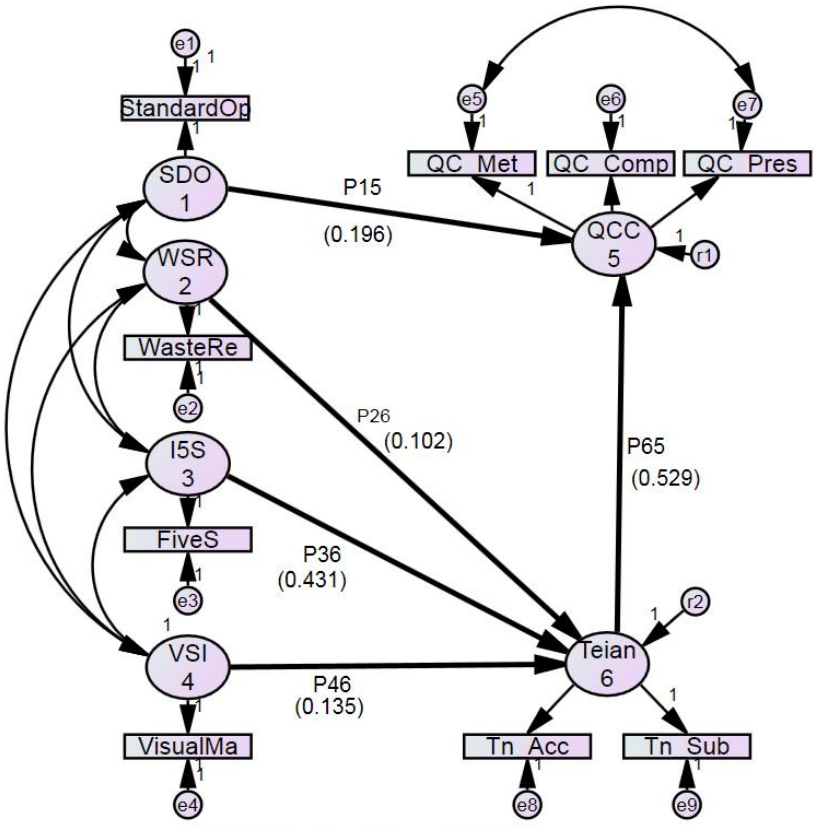


Figure 7.7: The modified model (a), the bold paths are shown for the current study (AMOS Graphics)

Accordingly, the path effects of the shop floor management tools on the two improvement practices were used to test the first hypothesis (**H1**) of the study: the four building shop floor management tools had positive effects on the two improvement practices. However, the results were only able to prove four of the eight direct paths, and thus, only four sub-hypothesises were supported (Table 7.23).

	Hypotheses	Result
H1a (P15)	Implementation of standard operations has positive effects on QCCs	**Supported**
H1b (P25)	Implementation of waste removal has positive effects on QCCs	Not supported
H1c (P35)	Implementation of 5S practice has positive effects on QCCs	Not supported
H1d (P45)	Implementation of visual management has positive effects on QCCs	Not supported
H1e (P16)	Implementation of standard operations has positive effects on *Teians*	Not supported
H1f (P26)	Implementation of waste removal has positive effects on *Teians*	**Supported**
H1g (P36)	Implementation of 5S practice has positive effects on *Teians*	**Supported**
H1h (P46)	Implementation of visual management has positive effects on *Teians*	**Supported**

Table 7.23: The path estimates and results for the H1 testing

Figure 7.7 shows that a new path (**P65**) was created. Therefore, three of the shop floor tools (waste removal, 5S practice, and visual management) had indirect effects (indirect paths) on one of the improvement practices (QCCs). Table 7.24 shows the indirect effects and the calculated total effects.

	QCCs
Waste removal	.054 (**P26** × **P65**)
5S practice	.228 (**P36** × **P65**)
Visual management	.071 (**P46** × **P65**)

Table 7.24: Indirect path effects from shop floor management to the two improvement practices

These shop floor tools had significant effects (either directly or indirectly) on QCCs and *Teians*. Table 7.25 shows the calculated total effects that the four shop floor tools had on the two improvement practices.

	QCCs	*Teians*
Standard operations	.196 (direct)	-
Waste removal	.054 (indirect)	.102 (direct)
5S practice	.228 (indirect)	.431 (direct)
Visual management	.071 (indirect)	.135 (direct)

Table 7.25: Total path effects from shop floor management to the two improvement practices

7.4.2 The overall ML estimate results for model (b)

The modified model (b) was a recursive model. The model showed the relationships between the two improvement practices and the four improvement outcomes. Figure 7.8 shows the modified model (b) and its standardised paths estimates.

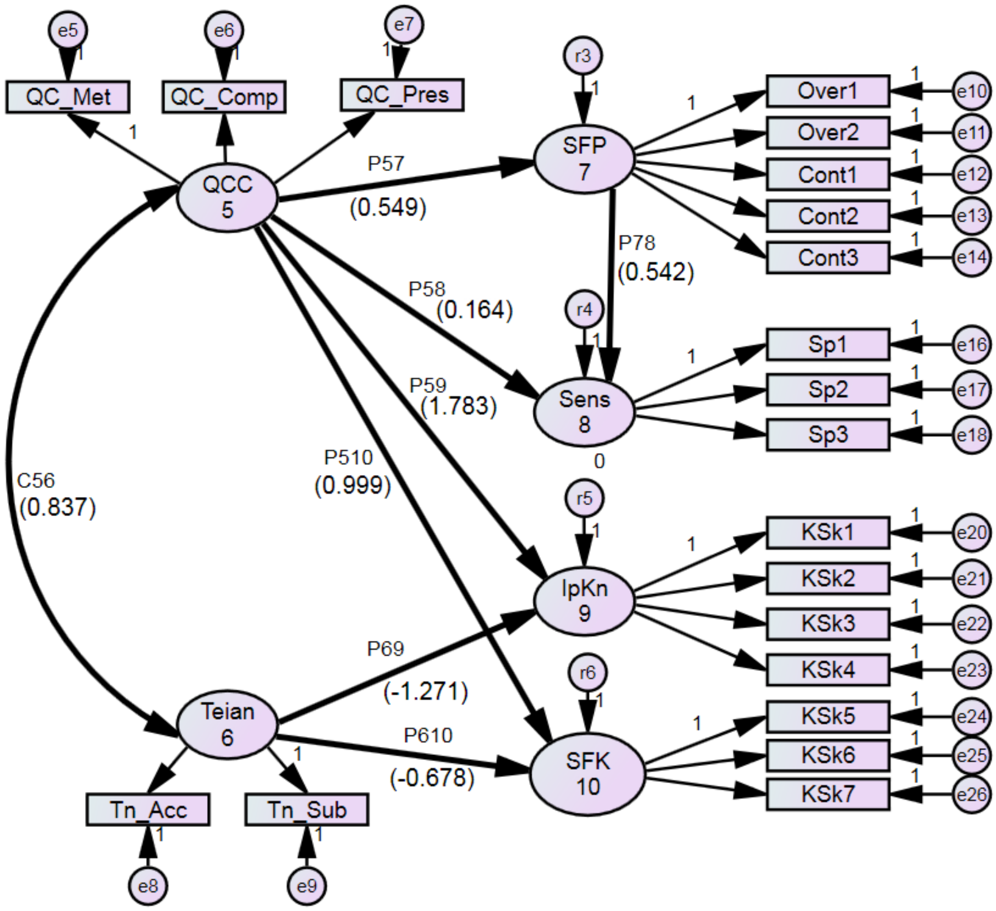


Figure 7.8: The modified model (b), the bold paths are shown for the current study (AMOS Graphics)

	Hypotheses	Result
H2 (C56)	The two improvement practices are mutually supportive	**Supported**
H3a (P57)	QCCs have positive effects on *shop floor performance*	**Supported**
H3b (P58)	QCCs have positive effects on *sense of participation*	**Supported**
H3c (P59)	QCCs have positive effects on *improvement knowledge*	**Supported**
H3d (P510)	QCCs have positive effects on *Shop floor skills*	**Supported**
H3e (P67)	*Teians* have positive effects on *shop floor performance*	Not supported
H3f (P68)	*Teians* have positive effects on *sense of participation*	Not supported
H3g (P69)	*Teians* have positive effects on *improvement knowledge*	Not supported
H3h (P610)	*Teians* have positive effects on *shop floor skills*	Not supported

Table 7.26: The path estimates and results for the H2 and H3 testing

Accordingly, the correlation between the two improvement practices was used to test the hypothesis (**H2**) that: the two improvement practices were mutually supportive; and the path estimates from the two improvement practices on four improvement outcomes were used to test the hypothesis (**H3**) that: the two improvement practices had positive effects on the four improvement outcomes. The results indicated that **H2** was supported, but only four **H3** sub-hypotheses were supported (Table 7.26).

Figure 7.8 shows that a new path (**P78**) was created. Therefore, QCCs would also have had indirect effects (indirect paths) on one of the improvement outcomes (Sense of participation). Table 7.27 shows the calculated total effects of the four shop floor tools on the two improvement practices.

	Shop floor performance	Sense of participation	Improvement knowledge	Shop floor skills
QCCs	.549 (direct)	.462 (total: **P57**× **P78** + **P58**)	1.783 (direct)	.999 (direct)
Teians	-	-	-1.271 (direct)	-.678 (direct)

Table 7.27: Total path effects from the improvement practices to the long-term outcomes

7.5 Summary

This chapter discussed the use of AMOS to specify and identify the SEM path model method to analyse the empirical data, shape the proposed theoretical model, and test the hypotheses. It described the development of the two models and the testing and the validation of the results. Furthermore, it also showed the results of the hypotheses testing. The next chapter will provide more detailed analyses, the implications of the results and the contribution to theory.

Chapter 8 Discussions and Implications of the Research Findings

This section presents a detailed analysis and interpretation of the results. First, it explains the results of the path analysis that was used to refine the hypotheses about the proposed causal relationships; and second, it interprets these relationships and describes the implications of the findings.

At this point in the study, a general word of caution needs to be inserted prior to the discussions of the PA results and their associated implications. In the exploratory and observational study, there could be a chance that the statistical relationship exists only because both independent and dependent variables were correlated, but does not imply causations. Thus, the independent variables might not in any way determine the level of a cause. However, the strong theoretical causality in the study has been developed and tested by previous research. In particular, based on the theory developed in previous studies (e.g., Handyside, 1997; Imai, 1997; Bateman and Brander, 2000), it was sensible to assume that shop floor management is one of the direct causes for implementing shop floor improvement activities. In addition, following some recent studies (e.g., Farris, 2006; Doolen *et al.*, 2008), it is also highly unlikely for these to have been reverse causality effects between the improvement activities and the proposed improvement outcomes. Therefore, confidence in the hypothesised direction of causality in the study was strengthened.

8.1 The Relationships Between Shop Floor Management Tools and Improvement

This study produced results which corroborated the findings of previous research. It confirmed the importance of shop floor management tools for instigating improvement. In addition, based on the quantitative research design, the degree of the importance was quantified and its impact on the two improvement practices was compared numerically.

8.1.1 The implications of the relationships observed between the four tools

Although not specified as testable hypotheses, questions of interest in this study also related to the implementation of shop floor management tools (As listed in Section 1.3). These questions were answered by measuring and comparing the overall use of each individual tool and the interrelationships were addressed through the calculations in AMOS.

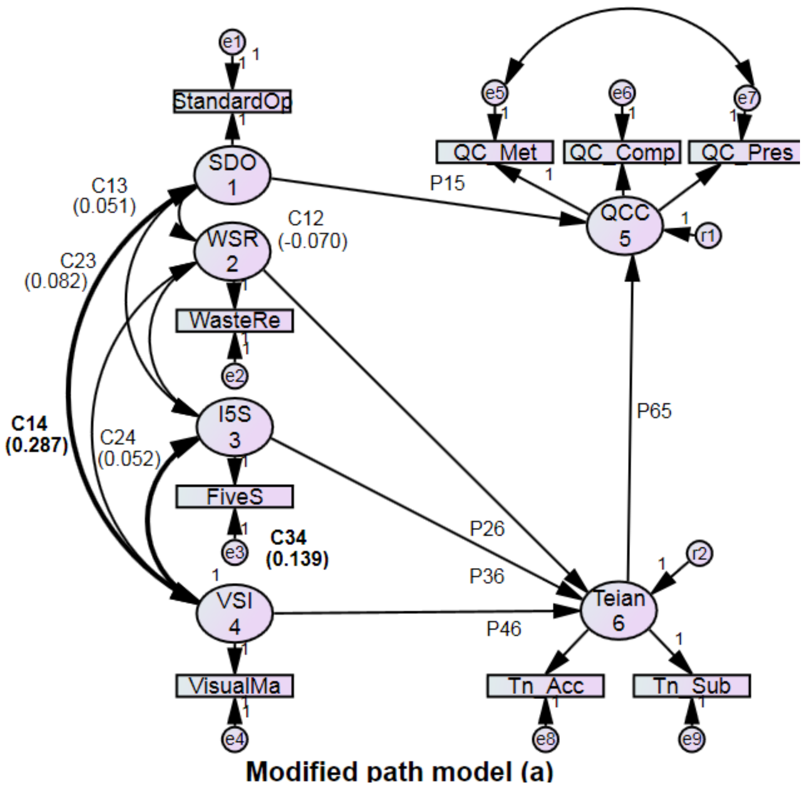


Figure 8.1 The correlations of the four building block tools section (AMOS Graphs, significant estimates shown in bold)

The exploration of the relationships between each of the shop floor tools aided the understanding of the importance of shop floor management tools in supporting the two improvement practices. These relationships were investigated in the modified model using AMOS (Figure 8.1) and the results obtained from the AMOS output are presented in Table 8.1.

Covariances (*Correlations*)	**SDO_1**	**WSR_2**	**I5S_3**	**VSI_4**
SDO_1	-			
WSR_2	-0.710 (*p=0.220*) (-0.070)	-		
I5S_3	0.670 (*p=0.361*) (0.051)	0.864 (*p=0.153*) (0.082)	-	
VSI_4	**3.374 (*p<0.001*) (0.287)**	0.495 (*p=0.365*) (0.052)	**1.708 (*p=0.014*) (0.139)**	-

Table 8.1 The covariance and correlation results from the modified model in AMOS Graphics

Previous research has suggested that the shop floor management tools are mutually interdependent (e.g., Handyside, 1997; Imai, 1997; Bateman, 2001; Toshiko and Shook, 2007; Herron and Hicks, 2008). However, as Table 8.1 shows, only two positive and significant correlations (shown in bold) were identified. For the participating companies there was only enough evidence to indicate two positive and significant correlations amongst the four building block shop floor tools. Thus, the assumed mutually interdependent relationships were only partially supported. These findings may appear to disagree with the existing literature (Imai, 1997; Bateman and Brander, 2000), as the use of the four building block tools were not all correlated with each other.

Although this research did not find significant evidence to prove all of the assumed correlations, this does not preclude them from having some indirect relationship. In this sense, it was possible that some unmeasured building block shop floor tools had been used by the respondents for implementing continuous improvement (e.g., Suzaki, 1993, p250). One possible reason was that the chosen measures did not fully capture all the building block shop floor management tools and their sequence of implementation in the case companies. In particular, using only a clear-cut way of measuring the use of shop floor management tools could simply have missed out some other potential building block tools, as the actual ways of shop floor management may vary from one company to another.

In addition, as Figure 8.1 above shows, none of the correlations that were negative were statistically significant. Consequently, this finding indicated that the shop floor management tools were not mutually exclusive. Hence, the findings confirmed previous research (Handyside, 1997; Imai, 1997; Bateman, 2001; Toshiko and Shook, 2007; Herron and Hicks, 2008) that these four building blocks tools are commonly implemented together. However, the lack of a strong correlation among the four tools could imply that the studied companies were at a sufficient stage of maturity that they had already implemented some shop floor management tools previously, which might not have been picked up by this research. To test this proposition, a holistic set of company-specified scales with sequence of implementation could be used in future research to measure the implementation of the shop floor management tools.

8.1.2 The implications of the relationships between the four tools and improvement

Next, the hypothesised relationships between the shop floor tools and the improvement practices (**H1**) were tested. This hypothesis was disaggregated into eight sub-hypotheses (**H1a-H1h**, Table 7.23) to represent the eight assumed relationships between the proposed shop floor management tools and the improvement practices.

The results indicated that the shop floor management tools provided an environment which encouraged the development of QCC and *Teian* improvement ideas. The implementation of these tools created a framework for employees to better identify improvement opportunities and construct improvement ideas. This confirms the results of previous studies that these tools are important for supporting continuous improvement (Osada, 1991; Handyside, 1997; Hino, 2006). Therefore, these shop floor management tools may have been employed as a "common approach" to solve shop floor problems (Bateman and Brander, 2000).

Based on the path results (Table 7.26), it is interesting to note that three of the four proposed building block shop floor tools (*5S practice*, *waste removal*, and *visual management*) showed direct effects on *Teians*, whilst only one (*standard operations*) impacted on QCCs (Figure 7.7). These findings may appear to disagree with the existing literature (Imai, 1997; Bateman and Brander, 2000), as not all of the four building block tools support both QCCs and *Teians*.

However, the result provides new insight into the relationship between the shop floor management tools and *Kaizen*. In the current study, the implementation of the four shop floor tools were measured by their frequency of use, and the implementation of the two *Kaizen* practices were measured by their quality and quantity. As such, it appears that the utilisation of 5S practice, waste removal, and visual management provided a better framework for encouraging *Teians* than QCCs. This may indicate that the high frequency use of these shop floor tools was mainly to uncover small-scale potential shop floor problems, which were then solved by the participants who were directly affected by using *Teians*. Another potential explanation is that the more the employees utilise the first three tools, the more *Teians* ideas they could develop and implement. According to some previous studies (e.g., Imai, 1986, pp., p5; Hirano, 1988; Kobayashi, 1990), the utilisation of these three tools helps to uncover local and small surroundings problems (or improvement opportunities), and thus supports *Teians* to provide immediate solutions. Whereas QCCs constitute a more formal improvement process, their implementation requires other specified knowledge (e.g. the use of statistical QC tools) and must follow a procedure or *standard* pattern of approach (e.g. QC story) (Akaoka, 1983; Inoue, 1985; Honda Motor, 1998; Ho, 1999, pp., p161; Fukui *et al.*, 2003; Farris, 2006). They may take long to response to this type of shop floor problems which, thus, were used less by the respondents.

The result also implies that QCCs were used to address problems relating to the implementation of standard operations. As defined in previous research (Hirano, 1988; Bodek, 2002; e.g., St. Pierre *et al.*, 2011, pp., p317), standard operations are organisation-wide detailed written instructions developed for achieving the uniformity of the performance of some specific functions. Therefore, making changes in standard operations may need to be carried out after conducting careful statistical analysis and should also be approved by senior management. Thus, they need to be improved by a formal improvement body which are led by shop floor supervisors and involve middle or senior managers, rather than by trial-and-error *Teians* (Lillrank and Kano, 1989; Ishikawa, 1990). QCCs should have greater authority than *Teians* to develop and implement improvement ideas for making wide-ranging changes. This finding may also imply that the QCCs are better for tackling large and priority-based improvements, rather than to dealing with fairly small and local shop floor problems.

In addition, a new path effect from *Teians* to QCCs was added to the model (Figure 7.7) to indicate a possible causal relationship between the two practices. That is *Teians* with a continuous basis are likely to provide better support for QCCs, as the large-scale improvements that based on the results of small and gradual changes are able to provide practical solutions. A possible explanation is that continuous *Teians* results provide regular milestones for QCCs which prevent the large-scale improvements backsliding to the pre-improvement stage. This supports previous studies (e.g., Ishikawa, 1980; Crocker *et al.*, 1984; Ishikawa, 1985a; Ishikawa, 1990; Suzaki, 1993; Recht and Wilderom, 1998; Masaki, 2006; Kupanhy, 2007; Toshiko and Shook, 2007) that *Teians* are best used for solving local shop floor problems to produce improvements in the immediate surroundings, whilst QCCs could be implemented for formulating activity plans and making department-wide/company-wide innovative changes. This also implies that only after small and local shop floor problems have been identified and resolved can large and innovative changes be successfully implemented.

Thus, the findings have some important implications: *first*, small shop floor problems need to be identified and solved quickly and continuously at source; because, *secondly*, innovative and dramatic changing methods (e.g., QCCs) may take long to fully address and implement, they are typically of 3-6 months duration and take place on a project basis; and *thirdly*, only the innovative and large-scale improvements that based on the results of small and gradual changes are able to provide practical solutions and prevent the results backsliding to the pre-improvement stage.

Finally, the findings of this PA model reaffirmed that shop floor tools help both *Teians* and QCCs. This confirms the results of previous studies (Choudri, 2002; Simons and Zokaei, 2005; Herron, 2007; Herron and Hicks, 2008) which found that that these building block tools should be employed in conjunction with *Kaizen* and *Kaikaku* (as *Kakushin*). This enables the full benefit of improvement to be achieved.

8.2 The Relationships Between the Improvements and Long-term Outcomes

Although the respondents in this research were randomly selected for inclusion, their participation in the two improvement practices was based on the companies' mandatory policies rather than their free will. This may have affected their perceptions reported in the questionnaires.

Based on the quantitative research design, the study results were quantified and compared numerically. The findings showed that the hypotheses were only partially supported. In particular, empirical data rejected some hypotheses about QCCs contributing to long-term improvement outcomes.

8.2.1 The implications of the mutual relationships between the two improvement practices

The hypothesis that the improvement practices were mutually supportive (**H2**) was confirmed (Table 7.26). A possible explanation might be a link between individual capabilities and group performance. Practically, the members of QCCs come together to share information, perspectives and insights to develop collective improvement ideas, but they also share skills, knowledge and experiences which are mutually reinforcing.

This result also confirms some previous studies that it is advantageous to implement both practices together (Kono, 1982; Huda, 1992; Elger and Smith, 1994; Bicheno, 2001; Bodek, 2004; Bessant *et al.*, 2005; Jones, 2005; e.g., Gåsvaer and von Axelson, 2012). The *Teian* provides an easier and less costly mechanism to identify immediate problems that are directly related to the individual proposer's working area (Schuring and Luijten, 2001). The *Teian* ideas are simple and can be implemented rapidly to provide incremental changes (Marin-Garcia *et al.*, 2008). In addition, the *Teian* includes a channel for ensuring that all workers participate (Japan Human Relations Association, 1997a) to contribute to their company's development (Brunet and New, 2003). Thus, over the long-term, the *Teian* fosters commitment and natural evolution to the company and Lean practices, which supports the application of QCCs (Ishikawa, 1990; Japan Human Relations Association, 1997a; Landsbergis and Cahill, 1999; Doolen *et al.*, 2008) and keeps alive a system of continuous improvement (Lawler and Mohrman, 1991).

8.2.2 The implications of the relationships between the improvements and the outcomes

The hypothesised relationship between the shop floor tools and the improvement practices (**H3**) was tested. This hypothesis was disaggregated into eight sub-hypotheses (**H3a-H3h**, Table 7.26) that represented the eight assumed relationships between the improvement practices and outcomes.

For the improvement outcome measure: *shop floor performance* (**SFP**), the PA results showed that QCCs exhibited a strong, significant and direct effect, whereas *Teians* had no direct effect (Figure 7.8). **SFP** was used to measure the perceived overall impact on the shop floor area (Doolen *et al.*, 2003). Therefore, from the PA results, implementing QCCs were important for improving *shop floor performance.* These findings are in line with some previous studies (e.g., Ishikawa, 1990; Huda, 1992; Shingo, 1992; Choi and Liker, 1995; Rapp and Eklund, 2002; Terziovski, 2002; Liker and Hoseus, 2008) in showing that QCCs could involve results-oriented and holistic changes, and they could generate more profound outcomes on the shop floor. In contrast, *Teians* focus on the process, in which the outcomes are small and always take time for the changes to take effect (Rapp and Eklund, 2002). Therefore, the outcomes are not always achieved immediately and may hard to be noticed on the shop floor (Rapp and Eklund, 2007; Marin-Garcia *et al.*, 2008).

Furthermore, the improvement outcome: *sense of participation* (**Sens**) is a factor that measured the extent of attitude change after participation in improvement activities

(Doolen *et al.*, 2003). The PA results, suggested that only QCCs had a positive and significant effects on this factor (Figure 7.8). In a further review of the PA results, QCCs also had an indirect effect through *shop floor performance* (**SFP**). The findings may imply that, in the case companies, the employees' willingness to engage in future improvement activities were based on both employees' current QCC improvement performance and their results. These findings are in line with some previous studies (e.g., Fairbank and Williams, 2001; Bodek, 2002; Marin-Garcia *et al.*, 2008) that the degree of implementation of the current improvements could affect the motivation to participate in future improvement activities.

Outcomes that relate to the technical aspects of problem-solving were measured using *shop floor skills* (**SFK**) and *improvement knowledge* (**IpKn**) (Doolen *et al.*, 2003). These measured the extent of the change arising from being involved in the improvement practices. The PA results suggested that the QCCs and *Teians* had opposite impacts on the two problem-solving capabilities (Figure 7.8). In particular, QCCs appeared to have had a positive effect on both factors, whereas *Teians* had negative effects. The latter finding was inconsistent with previous research which suggests that both *Teians* and QCCs should enhance problem-solving capabilities (Lillrank and Kano, 1989; Jomo *et al.*, 2001; Lillrank *et al.*, 2001; Fukui *et al.*, 2003; Gabriel, 2003; Farris, 2006). Many previous studies have indicated that hands-on *Teians* should result in improved *shop floor skills* (Yasuda, 1989; Japan Human Relations Association, 1997a; Neagoe and Marascu_Klein, 2009). According to the Japan Human Relations Association (1997a; 1997b), *Teians* are a learn-by-doing process that is based on the use of participants' shop floor experience and skills to identify problems and develop solutions. However, part of the *Teian* process involves some experimentation which requires the operators to modify standard work (Imai, 1986; Charles and Chucks, 2012). This could have negative effects on both process outcomes and the individual's ability to perform the standard operations. Furthermore, individual incentives for *Teians* (based upon participation, not results) (Yasuda, 1989) may have encouraged a plethora of suggestions, some of which may have been of little benefit. QCCs promote collaboration and facilitate team-based learning (Ishikawa, 1985a), whereas the *Teian* is focused on the individual so learning is only through personal reflection (Japan Human Relations Association, 1997b).

The results of the second PA model proved that QCCs had significant effects on all improvement outcomes, whilst *Teians* had negative effects on two outcomes. These findings only partially supported the third hypothesis. However, as an exploratory study, the empirical results have some important implications to enrich the continuous improvement knowledge. *Firstly,* the different impacts on the improvement outcomes have highlighted the fact that QCCs and *Teians* are different but mutually support practices for improvement. *Secondly*, the results indicated that the application of QCCs could have greater potential to generate more visible and holistic improvement results, and consequently can have a more significant impact on employees' motivation to future improvement activities. However, *thirdly*, organisations should monitor their *Teian* incentive schemes to carefully balance the need for improving participation with the adherence to best practice methods and standard operation procedures.

8.3 Summary

This chapter provided a detailed analysis of the observed relationships between the building block shop floor management tools and *Teians* and QCCs. It critically evaluated the findings from the research. The contribution to theory and practice were outlined. This is further explained in the next chapter which summarises the results, limitations and contributions of the research.

Chapter 9 Conclusions, Contributions and Directions for Future Research

This chapter summarises the research findings and identifies areas for further study. The chapter is divided into 4 sections: section 9.1 provides a summary of the research objectives and the extent to which the process of continuous improvement was implemented in Sino-Japanese automotive joint ventures. This section also summarises the literature relating to the implementation of the Japanese *Kaizen*. It describes the results of the model testing in order to answer the research questions. Section 9.2 provides an overview of the contribution to knowledge in the adoption of shop floor management tools and the implementation of the appropriate practices to support continuous improvement. Section 9.3 presents the limitations of this research and, finally, section 9.4 suggests areas for future research.

9.1 Summary of the Research Findings

This study has explored the implementation of the Japanese *Kaizen* in nine Sino-Japanese joint ventures. It investigated two fundamental practices, QCCs and *Teians*, to define their roles in *Kaizen* and explored whether their performance outcomes were different. The findings should improve the understanding of the relationships between the shop floor management tools, the two improvement practices and their improvement outcomes. Hence, the use of these two improvement practices provides a better structure for companies to achieve *Kaizen.* This study bridges the existing research gap in terms of addressing the long term adoption and implementation of continuous improvement in manufacturing companies located outside of Japan.

9.1.1 Conclusions on the implementation of the Japanese Kaizen

- The literature review showed that Japanese *Kaizen* is more than a simple improvement system. It is also a unifying and company-wide strategy, a philosophy, and the basis for long-term incremental process improvement. The implementation of the Japanese *Kaizen* is not a high technology improvement approach (Bartezzaghi, 1999). It does not always produce radical changes (Bicheno, 2001). Its implementation is “not of the breakthrough variety, but incremental in nature” (Bessant and Caffyn, 1997, p10). It is “an organisational-wide process of focused and sustained incremental innovation” (Bessant and

Francis, 1999, p1106), or "a habitual way of life in the organisation" (Handyside, 1997, p14). The Japanese *Kaizen* instils in everyone within the organisation a sense of responsibility for implementing improvements following Deming's PDCA cycle on a continuous basis, for example habitually providing suggestions and implementing group-based improvement activities.

- The results of this study reaffirm that Japanese *Kaizen* can be applied in companies which are located outside of Japan. They also indicate that the success of its application begins on the shop floor, is underpinned by the application of the shop floor management tools and employees' ideas for improvement derived from their daily work experience. These improvement ideas form the basis of the Japanese *Kaizen*, and thus, they need to be considered regularly and continuously for long-term implementation.

9.1.2 The two Kaizen practices: Teians and QCCs

- The implementation of the Japanese *Kaizen* includes two different improvement practices. They are QCCs and *Teians*. Both of them can be employed for identifying, analysing and solving work-related problems.

	QCCs	***Teians***
Group size	Small number of employees (about 5-15)	Individual
Members	line supervisor(s) and employees from similar working area/department	Anyone
Participation	Voluntary	Spontaneous
Skills requirement	Statistical skills on QC tools	Shop floor production knowledge
Target problems	Department-/company-wide	Proposer's immediate working area
Problem sizes / scale	Large	Small
Implementing procedure	QC story	*Teian* cards
Time span	meet regularly for 6 months	Immediately
Frequency	One-off	Continuously

Table 9.1 The comparison of characteristics between QCCs and *Teians*

- The implementation of these two practices is different in many ways (Table 9.1). A QCC is a group-based activity comprising a small number of voluntary employees (small enough to allow face-to-face communication) who meet regularly and share ideas and expertise for instigating improvements. They rely on the support from line supervisors and top management, and focus on group decisions to develop improvement themes with specific and measurable goals. In contrast, the *Teian* is an individual suggestion scheme which is based on individual employees' willingness to make hands-on improvements to their work areas.

- Both *Teians* and QCCs could be used to collect process-oriented improvement ideas on how to solve immediate problems that are directly related to the individual proposer's working area. However, this study found that QCCs could also be utilised for gathering collective suggestions on how to make changes and improvements at department/organisational level. QCCs, similar to QCTs (Quality Control Teams, as described in Ishikawa, 1990), could also be used to formulate large change plans/improvement themes for priority-based improvements. In this sense, this study suggested that QCCs could collect result-oriented improvement ideas to produce dramatic changes for *Kaikaku*.

9.1.3 The relationship between the two Kaizen practices

- Although QCCs and *Teians* are two distinctly different improvement practices, this study discovered that they are mutually supportive. They not only mobilise the employees to participate in small and local process improvement initiatives, but they also increase employees' knowledge and skills to make high quality proposals for company-wide innovative changes. This supports the findings of Kondou (2003) and many other researchers (e.g., Kono, 1982; Huda, 1992; Elger and Smith, 1994; Handyside, 1997; Bicheno, 2001; Bodek, 2004; Jones, 2005; Murata, 2007) who argued that when implemented together (as *Kakushin*) the two practices could optimise the number of improvement ideas from employees.
- The research also demonstrated that it is necessary to implement *Teians* before QCCs on the shop floor. As the PA (path analysis) results indicated, the more that small and local problems are identified and resolved, the more the large and company-wide changes can be successfully implemented, but not *vice versa.* These findings follow in the footsteps of previous *Kaizen* research (Bateman, 2001; Kondou, 2003; Bateman, 2005; Toshiko and Shook, 2007) and additionally include some important implications. Shop floor problems need to be identified and solved quickly and constantly at source. This is because, innovative and dramatic changes may take long to respond to the problems and can be hard to implement continuously. Therefore, only innovative and large-

scale improvements based on the results of small and gradual changes can provide practical solutions and prevent the results backsliding to the pre-improvement stage.

9.1.4 The building block tools of shop floor management

- The literature review concluded that shop floor management contains many tools and techniques (Handyside, 1997; IEE, 1997; Imai, 1997, pp., p20; Feld, 2001; Liker, 2004). They are transferable and the essential components of shop floor maintenance.
- However, only four tools are mentioned many times and accepted as the building block tools to identify and solve shop floor problems (Bateman and Brander, 2000; Bateman and David, 2002; Bateman, 2005; Industry Forum, 2008). These are the 5S, waste removal, standard operations, and visual management. The importance of these four building block tools was demonstrated statistically.

9.1.5 The implementation of the shop floor management tools

- It has been suggested that the shop floor management tools is merely a set of housekeeping tools that tidy up the shop floor area and improve health and safety (Miom and Caropenter, 2000; Becker, 2001; Eckhardt, 2001; DiBarra, 2002). This research further identified that the tools for shop floor management is also a powerful guide which provides discipline and introduces order on the shop floor to maximise shop floor performance, and hence reduce variation in standardised processes. Additionally, the findings confirm that the implementation of the building block tools can help to uncover many hidden shop floor problems and identify their root cause. Thus, adopting these tools provides the potential for improvement. The correct implementation of shop floor management tools is deemed to be the beginning of the improvement journey.
- It seems that shop floor management could be adopted without major difficulty. As identified in the literature review, adopting and implementing most of the shop floor tools individually is not difficult, and many general guidelines are

well documented and readily accessible in the academic literature (e.g., the shop floor series books published by Productivity, Inc. 1998).

- However, adopting these tools in a holistic approach to support improvement could be difficult. This research concluded that the shop floor management tools was not an 'off the shelf' product, but that it was continuously evolving. Thus, there are some issues that need to be considered when adopting these tools to support long-term and continuous improvement. *Initially*, the majority of these tools have the simple purpose of removing waste, increasing communication clarity, improving shop floor safety or standardising shop floor activities. Therefore, most of these aspects would not automatically result in improvement, but their correct implementation could contribute to revealing many hidden problems. *Additionally*, most of these tools have no long-term effects, thus, they need to be implemented on a regular basis to serve the long-term improvement activities. *Furthermore*, there could be more than one way of implementing each of these tools (e.g., see Section 3.2-3.5). The adoption of shop floor management tools should be reality-oriented rather than concept-oriented (Ishikawa, 1990). As Suzaki (1993) and Osono et al. (2008) argued, the implementation of shop floor management tools is for 'Three Reals': *genba*, *genbutsu* and *genjitsu* (Japanese for real scene or shop floor, real thing and real fact, 現場現地現物, or go to see the place and collect the data from where the problem is occurring).

9.1.6 The role of shop floor management in supporting Kaizen

- The findings demonstrated that the implementation of shop floor management tools was a key to instigating shop floor changes. A successful long-term and sustainable improvement should begin with the application of correctly applied shop floor management. The PA results provided evidence that the more the employees utilise the building block tools, the more shop floor hands-on skills and experience they can develop and, eventually, better quality improvement ideas can be proposed.
- A significant result was that the regular use of the building block tools may directly increase employees' maintenance experience and shop floor skills to develop *Teians*.

- On top of that, the result also indicated that the regular use of the building block tools could indirectly provide a framework to maintain shop floor order and discipline. This important feature would enable a reduction in variations and help to identify any unnecessary production processes. Therefore, they could lead to the improvement in standard operation procedures via QCCs.

9.1.7 Conclusions on the relationship between improvement practices and outcomes

- This research strongly supports the view that the implementation of the two practices together could create more implementable ideas and deliver better improvement results on the shop floor. Added to this, through participation in both improvement practices, employees can further develop their knowledge, skills and motivations for subsequent improvement activities. Therefore, the findings explained how, together, these two practices could assist employees to deliver continuous improvement.
- The results showed that QCCs had a statistically significant and positive impact on all of the improvement outcomes. To the contrary, the advantage of using *Teians* was less obvious or could have been overstated in the literature. It is possible that individual incentives may encourage a plethora of experimentation that is not value adding. Furthermore, *Teians* could be partly responsible for the variation from standard working practices. Hence, there is a tension between the rigidity required to promote standard work and the necessary flexibility required to encourage innovation. Accordingly, the implementation of *Teians* would not always have positive effects on the improvement outcomes.
- However, despite the fact that QCCs may have better improvement results than *Teians*, previous research (e.g., Rapp and Eklund, 2002) has not recommended to start directly with the group-based improvements. This study also identified that improvements that start with *Teians* are easier to implement and better to prevent the results backsliding to the pre-improvement stage.
- In addition, there was a strong correlation between QCCs and *Teians*, indicating that there is a significant benefit in implementing the two practices together. The implementation of *Teians* helped underpin a Lean culture and promoted participation. The outcomes from the QCCs were improved by the implementation of *Teians*, which could be a justification for their

implementation. This confirmed the results of previous research that suggested that QCCs and *Teians* are mutually supportive (Kono, 1982; Huda, 1992; Ma *et al.*, 2010).

- Taken together, these results confirmed that participating in both practices was not only essential for bringing in one-off changes to the shop floor, but was also critically important for improving participants' knowledge and skills, and maintaining their positive attitude towards continuous improvement activities.

9.2 Contributions of this Research

The research contributes to the general body of knowledge concerning the applicability of continuous improvement or *Kaizen* in Sino-Japanese autotmovie joint ventures. Based on the findings generated from the SEM path analyses, it can be confirmed that continuous improvement is not Japanese specific and can be implemented by most companies located outside of Japan. Its application may be successfully implemented through the combination of the two important practices: *Teians* and QCCs, and with the aid of shop floor management tools. This is a significant finding, as the important relationship between the two practices has been observed during the fieldwork and proven quantitatively.

In particular, this research was probably the first to study the relationships between the shop floor management tools, QCCs and *Teians* that used Structural Equation Modelling. It contributes to the body of knowledge by determining the role of these shop floor tools in supporting continuous improvement. The study focused on a set of shop floor tools which have been considered to be the building block tools (here defined as 5S, waste removal, visual control and standard operations).

The results showed that the four building block shop floor management tools should be applied regularly to provide a framework and initial ideas for long-term changes. All of the companies where the research was conducted encouraged their employees to implement these tools to eliminate waste and reduce variations in the standardised processes, and then to consistently implement them to detect hidden potential problems and identify their root causes. Once all of the problems were identified, the knowledge and experience gained was used to sustain continuous improvements. A good simple rule is to continuously apply these tools to assist in identifying shop floor problems and developing the necessary personal knowledge and experience for implementing improvements. This finding particularly helps in explaining the different effects of the building block tools on the two *Kaizen* practices. It postulates that the implementation of these tools is the basis for employees to identify improvement opportunities and construct improvement ideas for *Teians*. This postulation confirms the propositions of many previous studies that these tools are not only recognised as the beginning of the improvement cycle (Handyside, 1997), but they are also widely used to support improvement on a continuing basis (Osada, 1991). Therefore, shop floor management tools can be employed as a "common approach" to source shop floor problems (Bateman and Brander, 2000) and adopted as a MasterClass process to drive the improvement journey and result in enhanced product and performance outcomes (Bateman, 2001).

<table>
<tr><th colspan="2">Improvement steps</th><th>QCCs (for Kaizen and Kaikaku)</th><th>Teians (for Kaizen only)</th></tr>
<tr><td rowspan="5">Identification</td><td>Identifying Problems</td><td rowspan="4">Set up targets
(part of/linked with the company's long-term targets)</td><td rowspan="3">Identify problems
(through shop floor management)</td></tr>
<tr><td>Collecting data</td></tr>
<tr><td>Analysing data</td></tr>
<tr><td>Setting up target</td><td rowspan="2">Develop ideas for changes
(personally by shop floor knowledge, skills and experience)</td></tr>
<tr><td>Identifying root causes</td><td>Statistical analysis
(in group-based and apply QC tools)</td></tr>
<tr><td>Development</td><td>Setting up change steps</td><td>Brainstorming
(collective ideas)</td><td rowspan="3">Implementing changes to solve problems
(trial and error process)</td></tr>
<tr><td rowspan="2">Implementation</td><td>Implementing changes</td><td>Seek approval before implementing,</td></tr>
<tr><td>Evaluation</td><td rowspan="2">Evaluate results for spreading</td></tr>
<tr><td>Sustain</td><td>Standardisation</td><td>Approval and spread</td></tr>
<tr><td colspan="4">QCCs:
• Have larger improvement targets than Teians and have better support for substantial changes;
• Meeting regularly helps to share not only improvement ideas, but also knowledge, skills and experience amongst employees and between departments;
• Comprehensive data collection and statistical data analysis ensure the quality of the solutions; and
• Provide an important interface between employees and managers.
Teians:
• Making personal suggestions helps to develop skills to spot abnormal situations;
• Simple written suggestions provide immediate solutions to small and surrounding problems;
• Written solutions help the sharing and review of ideas; and
• Provide opportunities for management to monitor skill development of each individual participant.</td></tr>
</table>

Table 9.2 The specified use of QCCs and *Teians* when they are employed together

Furthermore, this research contributes an empirically-tested theory for managing the two *Kaizen* practices (QCCs and *Teians*) by comparing their effectiveness in supporting continuous improvement. Although the differences between the two practices are significant (Table 9.2), it is feasible to apply them together. All of the companies appear to have used both practices to collect and utilise improvement ideas. Therefore, this research also suggests that the two practices can be more effective in sustaining improvement and innovation when applied together, regardless of the nature of the problem.

The thesis concludes that *Kaizen* can be adopted by any organisations to support continuous improvement. This is particularly important for organisations that are planning to implement Lean Production. One view is that a company's culture may inhibit the implementation of *Kaizen* (e.g., Liker and Hoseus, 2008). However, the research identified the building block shop floor management tools that can be implemented to sustain its long-term implementation. Companies require a balanced structure in order to facilitate continuous improvement, and that shop floor management tools are a powerful aid to this process (Figure 9.1). It has the objective of providing discipline, and introducing order and standards onto the shop floor. The regular application of these tools will highlight any variations in standardised procedures and identify their root causes.

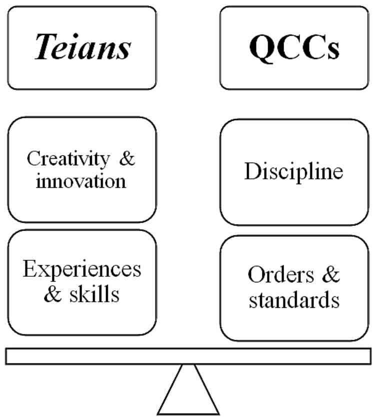


Figure 9.1 A balanced structure to facilitate continuous improvement

To achieve long-term, sustainable improvement requires both the willingness of employees to embrace change, as well as applying the two improvement practices in the appropriate order. *Teians* should be implemented first and then QCCs. The two practices combine together to form the *Kakushin* (to compare with the Japanese model identified in Section 2.3.2 and the improved model in Section 3.1) which can have a better result in sustaining continuous improvement and generating long-term outcomes than applying either approach in isolation (Figure 9.2 vs. Figure 2.12 and Figure 3.1). The objective is to achieve the long-term development of a Lean culture without compromising short-term performance.

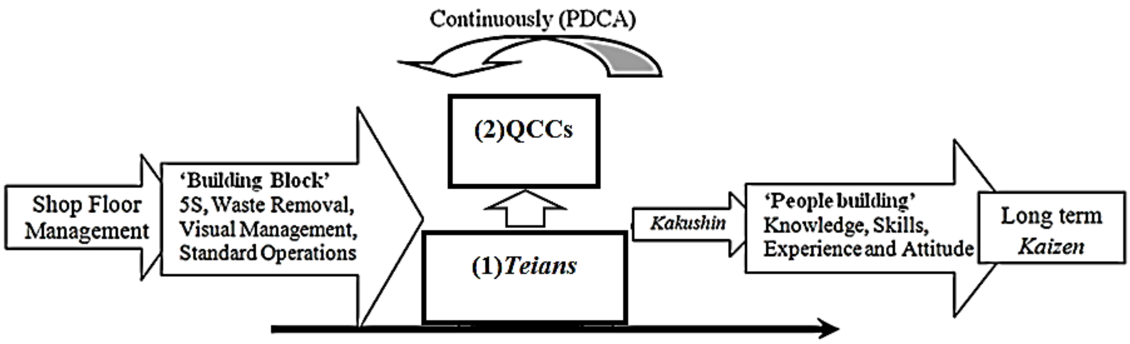


Figure 9.2 The improved model of *Kaizen* implementation

9.3 Limitations

- The sample size of the current study was limited in terms of the number and location of participating companies which may impact on the generalisability of the study.

  The survey was conducted in 9 case companies in Guangzhou, a city in southern China. A total of 900 questionnaires were self-administered in these case companies, 398 copies were collected back of which 371 were considered usable for data analysis. Although the response rate of approximately 41.2% was accepted in similar studies (Farris, 2006; Glover, 2010) and considered adequate as exploratory research (Krishnaswamy *et al.*, 2009; Lohr, 2009) and in the method of probability sampling for survey-based research strategies (Rungtusanatham *et al.*, 2003; Saunders *et al.*, 2007; Karlsson, 2009), a larger data sample is recommended in future research to include more companies from a wider area.

- The participating companies were all in the automotive industry and had close relationships with their Japanese partners.

  The 9 Sino-Japanese joint ventures were all in the automotive industry and they could be highly influenced by their Japanese partners to have good knowledge, skills and experience to implement continuous improvement. This suggests that for a better understanding of the applicability of the practice, future research should include companies which also have experience in implementing continuous improvement, but with less Japanese influence and possibly from other industries.

- The importance of national culture was excluded in the study.

The support of both the Japanese national and corporate culture to implement improvement has been discussed in previous research (Hofstede, 1998; Herron and Hicks, 2008; Liker and Hoseus, 2008). The importance of establishing a culture of continuous improvement was observed in the case companies. However, the focus of this study was on the application of shop floor management tools to support improvement. Future research could focus on how Chinese companies may be able to foster a culture of continuous improvement. This would include examining the type of human resource management policies and practices (e.g., training, selection, assessment and incentives) that are required in a Chinese context to support long-term change.

– Only four of the most commonly cited building block tools were evaluated in the research.

  This research did not investigate all of the available shop floor management tools. The reason for choosing the four was that they are the most commonly used and cited tools. Their importance has been physically observed and statistically proven in the current study. The rationale for not choosing any of the less commonly cited tools was that they were unlikely to be used by all of the companies in this study. However, the evaluation of additional common tools could be used in further studies to compare and contrast their effects on continuous improvement with the four common building block tools.

– It is possible that not all of the relevant dependent/independent variables and their causal relationships were obtained.

  Due to the exploratory nature of the research, the proposed causal relationships may require additional controlled experiments for model testing. In addition, it should also be noted that, as an observational study, there could be a chance that the statistical relationship exists only because both independent and dependent variables are correlated or there may be a random relationship between the two types of variables; therefore causation may not have been correctly identified. Thus, the independent variables might not in any way determine the level of a cause. These issues, in part, were considered in Chapter 8. *First*, the strong theoretical causality in the research had been developed and tested by previous research. It is reasonable to assume that the implementation of shop floor management tools has a direct impact on shop floor improvement. *In addition*, following some recent studies, it is also highly unlikely to be due to reverse causality effects between the improvement activities and the proposed improvement outcomes.

9.4 Areas for Future Work

Through the empirical findings from the selected automotive joint ventures, the research was able to prove the applicability of continuous improvement in companies located outside of Japan. However, results could be more robust and accurate if additional work was conducted to increase the generalisability of the study and extend the research to a wider area. Thus, future research could investigate the following:

1. Increase the sample sizes, extend the participating company case studies from the automotive industry to other industries (including the service industry) and expand to a broader context:
   - to assess the stability of the models developed in this research;
   - to develop a better SEM model fit (by using a different estimation method in AMOS (e.g., UL when there is a larger sample size); and
   - to compare and contrast the results of the current study (by using ‘company’, ‘industry’ and ‘location’ as the control factors).

2. Include national culture of the relevant country as well as the company culture as the control factors to compare and contrast the results of the research;
3. Include human resource management policies and practices (e.g., training, selection, assessment and incentives) as another control factor to compare and contrast the results of the current study;
4. Include additional common shop floor management tools:
   - to determine their role in shop floor management;
   - to identify their sequence of implementation;
   - to compare and contrast their use in each of the case companies; and
   - to compare and contrast their effects with the original four building block tools in supporting continuous improvement.

5. Consider the use of the SEM programmes other than AMOS to perform the Path Analysis from the collected data.

Finally, *Kaizen* “is not a new word for suggestion schemes, a more fashionable term for quality circles or ‘improvement teams’, or a tool or methodology for problem solving” (Handyside, 1997, p9). The basis of the Japanese *Kaizen* is the endless quest for continuously identifying problems and providing solutions. Adopting *Kaizen* may become easier with a continuous effort to also identify its critical factors and the implementing practices according to different local settings.

Appendices

Appendix A

Authors	Building Block Tools identified for maintenance and improvement
Toyota Motor Corporation (1998) GAC-Toyota (2008)	• Standardisation/standard operations • Employees motivation and commitment • 5S practice • Visual Control • Standardisation / standard operations • Waste removal
Imai (1986) Kupanhy (2007)	• 5S practice • TPM • Visual Control • Standardisation/standard operations • Waste removal
Handyside (1997) IEE (1997)	• Motivation, teamwork skills, commitment • 5S practice • Problem solving tool (value stream analysis) • TPM, • Visual Control • JIT/*kanban* • Right first time, *poka yoke* • SMED • PDCA cycle
Alukal (2006) Bateman(2005) Bateman and Brander (2000) Choudri (2002) Industrial Engineer (2008) Suzaki (1993) Toshiko and Shook (2007)	• 5S practice • Waste removal • Visual management • Standardisation / standard operations
Huda (1992)	• PDCA cycle • Standardisation/standard operations • Waste removal • Right first time, *poka yoke* • *Jidoka* • Just-in-Time

The building block tools for shop floor maintenance and improvement, adopted from the major shop floor specified studies

Appendix B

Stages	Definitions by Osada	Some other definitions and usages
seiri/organisation	Organising items in accordance with specific rules or principles	Get rid of all unnecessary items
s*eiton*/orderliness	Having things in the right places or layout	Locate all necessary items in their own visually marked place “a place for items essential to the manufacturing process is visually identified” (Bateman and Brander, 2000, p242) “establishes ‘checks and balances’ to ensure that the new process is maintained” (Ansari and Modarress, 1997, p393) “development of control techniques to ensure adherence to overall standards” (Becker, 2001, p29)
seiso/cleanliness	Getting rid of waste, grime and making things clean; a form of inspection	Clean the area and its equipment, assess its condition and identity problems and irregularities “maintain order, sweep, and clean” (Hobbs, 2004, p131) “documenting the new process and making provisions for necessary changes, new items and workers” (Ansari and Modarress, 1997, p393) “a daily cleaning process” (Becker, 2001, p30) “Systematic cleaning ensures that the area is neat and ready for inspection” (DiBarra, 2002, p143)
seiketsu/ standardised cleanup	Continually and repeatedly maintaining the organisation’s neatness and cleaning	Introduce standards, routines and training “Practice management discipline” (Hobbs, 2004, p131) “simplifying and organizing items needed” (Ansari and Modarress, 1997, p393)
S*hitsuke/* discipline	Establishing the habits and discipline on creating 5S practice in previous stages	Introduce procedures and systems which maintain and improve these practices by all employees “It is Management’s responsibility to reinforce and demonstrate leadership” (Hobbs, 2004, p131)

The definition of 5S practice' tools by various authors

Appendix C

The developed English version of the questionnaire:

Continuous Improvement Survey

This survey examines the shop floor motives, targets and means your organisation has chosen to promote, support and sustain continuous improvement activities.

Confidentiality

All replies to this questionnaire will be treated as CONFIDENTIAL. Information on the composite finding that emerges from the questionnaire will be available to all respondents as soon as possible.

You and your organisation's identity will not be disclosed without your approval. The results will be used in aggregate form in any publication.

For each question, please indicate the response(s) by ticking the corresponding box(es), or by writing in the answer.

a. General questions on you in the organisation.			
Your qualification	☐Secondary/college or below	☐Bachelor Degree	☐Master Degree or above
Job title in the organisation	☐ Shop floor worker	☐Line supervisor	☐ Manager
Years in the organisation			___Year(s)
Years of participating in improvement activities			Year(s)
QCC group position		☐ Member	☐ Leader/facilitator

b. General information on shop floor continuous improvement		
1. In general, how many times do you meet every month for QCC? ______ time(s)/month		
2. In general, how long does each QCC meeting last? ______ hour(s)/time		
3. How many group members were there in your last QCC group? ______ person(s)		
4. How many QCC themes did your group complete last year? ______ theme(s)		
5. How many QCC conferences did you attend last year? ______ time(s)		
6. How many times did you present in these QCC conferences? ______ time(s)		
7. The members from your QCC group are		
O Mainly from the same shop floor	O Mainly from the different shop floor	O About the same
8. Your QCC improvement themes were always		
O Part of the organisation-wide improvement projects	O randomly picked by the group	O About the same
9. You have spent more time on		
O QCC group activities for improvement	O *Teians* for improvement	O I have spent about the same amount of time on QCCs and *Teians* for improvement
10. How many *Teians* did you submit in the last 12 months? ______ *Teian*(s)		
11. How many of these *Teians* were accepted for implementation? ______ *Teian*(s)		
12. How many improvement training sessions have you attended in the last 12-month period? ______ session(s)		

c. Implementation of 5S practice	1 Never	2 Very rarely	3 Rarely	4 Occasionally	5 Frequently	6 Very Frequently	7 Always
13. *Seiri* (Organisation)	☐	☐	☐	☐	☐	☐	☐
14. *Seiton* (Neatness)	☐	☐	☐	☐	☐	☐	☐
15. *Seiso* (Cleaning)	☐	☐	☐	☐	☐	☐	☐
16. *Seiketsu* (Standardisation)	☐	☐	☐	☐	☐	☐	☐
17. *Shitsuke* (Self-discipline)	☐	☐	☐	☐	☐	☐	☐

d. Use of the standard operations sheet	1 Never	2 Very rarely	3 Rarely	4 Occasionally	5 Frequently	6 Very Frequently	7 Always
18. Quality control sheet	☐	☐	☐	☐	☐	☐	☐
19. Production standard sheet	☐	☐	☐	☐	☐	☐	☐
20. Work standard sheet	☐	☐	☐	☐	☐	☐	☐
21. Work procedure sheet	☐	☐	☐	☐	☐	☐	☐

e. Implementation of waste removal	1 Never	2 Very rarely	3 Rarely	4 Occasionally	5 Frequently	6 Very Frequently	7 Always
22. Waste identification	☐	☐	☐	☐	☐	☐	☐
23. Waste elimination	☐	☐	☐	☐	☐	☐	☐
24. Waste prevention	☐	☐	☐	☐	☐	☐	☐

f. Use of visual management	1 Never	2 Very rarely	3 Rarely	4 Occasionally	5 Frequently	6 Very Frequently	7 Always
25. Visual indicator	☐	☐	☐	☐	☐	☐	☐
26. Visual signal	☐	☐	☐	☐	☐	☐	☐
27. Visual control	☐	☐	☐	☐	☐	☐	☐
28. Guarantee	☐	☐	☐	☐	☐	☐	☐

g. The overall perceived performance of improvement activities	1 Strongly disagree	2 Disagree	3 Slightly disagree	4 Neither agree nor disagree	5 Slightly agree	6 Agree	7 Strongly agree
29. Overall, the performance of my improvement activities was a success in my company	☐	☐	☐	☐	☐	☐	☐
30. Overall, my improvement activities were vital in my company	☐	☐	☐	☐	☐	☐	☐
31. My improvement activities had a positive effect on the shop floor area	☐	☐	☐	☐	☐	☐	☐
32. This shop floor area improved measurably as a result of my improvement activities	☐	☐	☐	☐	☐	☐	☐
33. My improvement activities have improved the performance of this shop floor area	☐	☐	☐	☐	☐	☐	☐
34. I liked taking part in the current improvement activities	☐	☐	☐	☐	☐	☐	☐
35. I would like to take part in the improvement activities in the future	☐	☐	☐	☐	☐	☐	☐
36. In general, I am comfortable working with others to identify improvements on my shop floor area	☐	☐	☐	☐	☐	☐	☐
37. Overall, the improvement activities increased my knowledge of what CI is	☐	☐	☐	☐	☐	☐	☐
38. In general, the improvement activities increased my knowledge of how CI should be applied	☐	☐	☐	☐	☐	☐	☐
39. Overall, the improvement activities increased my knowledge of the need for CI	☐	☐	☐	☐	☐	☐	☐
40. In general, the improvement activities increased my knowledge of my role in CI	☐	☐	☐	☐	☐	☐	☐
41. I can communicate new ideas as a result of participation in improvement activities	☐	☐	☐	☐	☐	☐	☐
42. I gained new production skills as a result of participation in improvement activities	☐	☐	☐	☐	☐	☐	☐
43. In general, the participation in improvement activities motivated me to perform better	☐	☐	☐	☐	☐	☐	☐
44. Overall, the improvement activities increased my work interests	☐	☐	☐	☐	☐	☐	☐
45. Overall, the improvement activities helped me and my colleagues work together to improve performance	☐	☐	☐	☐	☐	☐	☐

Thank you for your co-operation!!

Appendix D

The Chinese translated version of the questionnaire:

关于持续改善的问卷调查

尊敬的朋友：您好

首先感谢你的合作及贡献出宝贵的时间。本次调查是纯粹的学术性的研究，所关心的是一些现场管理和持续改善之间的关系。希望您能够客观如实地填写问卷。本问卷调查为不记名形式，所有答案结果均保密且只会用于学习研究。

问卷主要包含了一些个人基本信息以及持续改善的问题，共包含三大部分共 45 道题目。第一部分收集基本个人信息，第二部分收集现场管理资料，第三部分收集所参与持续改善的结果。

本次调查没有时间限制，也没有对错之分，烦请按实际情况回答每一道问题。谢谢！

一．基本个人信息			
学历	☐ 中学或以下	☐大专或本科	☐ 硕士或以上
公司服务职位	☐生产现场工人	☐现场领班/安全员	☐管理人员
公司服务时间			____年
参与改善活动经验			____年
QCC 活动的职位	☐ 组员		☐ 组长

持续改善问卷调查

二．有关现场改善信息资料		
1. 所在 QCC 小组每月开会的次数大概是		______次/月
2. 所在 QCC 小组每次会议的时间大概是		
□大约半小时	□大约一小时	□多于一小时
3. 所在 QCC 小组的组成人数是		______人
4. 去年所在 QCC 小组能顺利完成主题的总数是		______件
5. 去年所在 QCC 小组共参与 QC 大会的次数是		______次
6. 有在这些 QC 大会上发表成果的次数是		______次
7. 所在 QCC 小组的成员		
□主要来自同一现场	□来自不同现场	□数量大概一样
8. QCC 所执行的任务主题是		
□公司改善计划的一部分	□成员挑选的现场改善主题	□数量大概一样
9. 所提交的个人改善提案		
□以小组 QCC 为主	□以个人改善提案为主	□数量大概一样
10. 去年提交个人改善提案的总数是		______件
11. 去年被同意执行个人改善提案的总数是		______件
12. 去年一共参与关于改善培训的次数是		______次

问卷在下页继续

1| 页

持续改善问卷调查

三．现场 5S 管理法的执行	从不参与			偶尔参与			频繁参与
13. 整理	☐	☐	☐	☐	☐	☐	☐
14. 整顿	☐	☐	☐	☐	☐	☐	☐
15. 清扫	☐	☐	☐	☐	☐	☐	☐
16. 清洁	☐	☐	☐	☐	☐	☐	☐
17. 素养	☐	☐	☐	☐	☐	☐	☐

四．标准作业的执行	从不参与			偶尔参与			频繁参与
18. 质量控制表	☐	☐	☐	☐	☐	☐	☐
19. 标准手持表(标准存货)	☐	☐	☐	☐	☐	☐	☐
20. 作业标准表	☐	☐	☐	☐	☐	☐	☐
21. 作业工序能力表	☐	☐	☐	☐	☐	☐	☐

五．减少浪费的执行	从不参与			偶尔参与			频繁参与
22. 寻找浪费	☐	☐	☐	☐	☐	☐	☐
23. 消除浪费	☐	☐	☐	☐	☐	☐	☐
24. 预防浪费	☐	☐	☐	☐	☐	☐	☐

六．目视管理的执行	从不参与			偶尔参与			频繁参与
25. 目视管理指示	☐	☐	☐	☐	☐	☐	☐
26. 目视管理判断	☐	☐	☐	☐	☐	☐	☐
27. 目视管理控制	☐	☐	☐	☐	☐	☐	☐
28. 目视管理修正	☐	☐	☐	☐	☐	☐	☐

问卷在下页继续

持续改善问卷调查

七．对现场改善活动结果的总体评价	完全同意			不确定			完全不同意
29. 我在生产现场的改善活动是成功的	□	□	□	□	□	□	□
30. 我的改善活动是生产现场的关键	□	□	□	□	□	□	□
31. 我的改善活动为生产现场带来积极的影响	□	□	□	□	□	□	□
32. 我的改善活动为生产现场带来可观的变化	□	□	□	□	□	□	□
33. 我的改善活动提高了生产现场的业绩和表现	□	□	□	□	□	□	□
34. 我对能成为实行持续改善的一分子感到满意	□	□	□	□	□	□	□
35. 我希望能继续参与未来的改善活动	□	□	□	□	□	□	□
36. 我很乐意去接受别人对我的现场工作提出改善的建议和意见	□	□	□	□	□	□	□
37. 让我增加了对持续改善的认识	□	□	□	□	□	□	□
38. 让我学习了持续改善的正确执行方法	□	□	□	□	□	□	□
39. 让我认识到执行持续改善的需求	□	□	□	□	□	□	□
40. 让我了解自己在执行持续改善中应该担当的角色	□	□	□	□	□	□	□
41. 为我创造了发表改善信息的机会和渠道	□	□	□	□	□	□	□
42. 让我学习新的现场生产技术	□	□	□	□	□	□	□
43. 激发我去发挥更好现场工作表现的潜能	□	□	□	□	□	□	□
44. 提高了我在现场工作的热诚和兴趣	□	□	□	□	□	□	□
45. 激励了我在生产现场与别人共同协作的精神	□	□	□	□	□	□	□

本次问卷调查到此完毕，谨在此再次感谢您抽出宝贵时间来参与本次调查！

3| 页

Appendix E

SPSS Descriptive Syntax

```
FREQUENCIES VARIABLES=QC_Me_Times___1 QC_Me_Length___2
QC_Mem_No___3 QC_Comp___4 QC_Con___5 QC_Pres___6
QC_Mem_S___7 QC_Theme___8 Improvement_focused___9
Tn_Sub___10 Tn_Acc___11 Training___12 I5S_1___13
I5S_2___14 I5S_3___15 I5S_4___16 I5S_5___17 SDO_1___18
SDO_2___19 SDO_3___20 SDO_4___21 WSR_1__22 WSR_2__23
WSR_3__24 VSI_1___25 VSI_2___26 VSI_3___27 VSI_4___28
Overall_1___29 Overall_2___30 Contribution_1___31
Contribution_2___32 Contribution_3___33
Sp_1___34 Sp_2___35 Sp_3___36 KnSk_1__37 KnSk_2__38
KnSk_3__39 KnSk_4__40 KnSk_5__41 KnSk_6__42 KnSk_7__43
KnSk_8__44 KnSk_9__45
  /ORDER=ANALYSIS.
```

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Com_1	4	14.8	14.8	14.8
	Com_2	5	18.5	18.5	33.3
	Com_3	1	3.7	3.7	37.0
	Com_5	4	14.8	14.8	51.9
	Com_6	8	29.6	29.6	81.5
	Com_8	4	14.8	14.8	96.3
	Com_9	1	3.7	3.7	100.0
	Total	27	100.0	100.0	

Deleted cases that contain missing values

Appendix F

Standardized Residual Covariances (Hypothesised Model a)

	QC_Pres___6	QC_Met	WasteRe	QC_Comp___4	Tn_Acc___11	Tn_Sub___10	FiveS	VisualMa	StandardOp
QC_Pres___6	.000								
QC_Met	-1.044	.000							
WasteRe	1.150	-1.034	.001						
QC_Comp___4	.439	.185	.093	.000					
Tn_Acc___11	**3.313**	**3.013**	2.183	**2.598**	.000				
Tn_Sub___10	**3.218**	**5.932**	-.561	**2.894**	.000	.000			
FiveS	-.662	.457	.003	-.372	-.354	-.013	.005		
VisualMa	-.070	1.759	.001	-1.350	-1.297	.294	.001	.000	
StandardOp	1.301	.419	.002	-.928	-.100	-.073	.004	.001	.001

Standardized Residual Covariances (Modified Model a)

	QC_Pres___6	QC_Met	WasteRe	QC_Comp___4	Tn_Acc___11	Tn_Sub___10	FiveS	VisualMa	StandardOp
QC_Pres___6	.032								
QC_Met	.064	.066							
WasteRe	1.302	-.845	.000						
QC_Comp___4	.328	-.112	.723	.030					
Tn_Acc___11	.673	-.765	2.547	.685	.000				
Tn_Sub___10	-.505	.509	-.275	.105	-.002	.000			
FiveS	-.889	.065	.000	.821	.078	-.003	.000		
VisualMa	-.701	.825	.000	-1.384	-1.249	.110	.001	.001	
StandardOp	1.012	-.051	-.016	-.017	.757	.965	-.034	-.013	.000

Appendix G

Standardized Residual Covariances (Hypothesised Model b)

	KnSk_8	QC_Pres	QC_Met	KnSk_7	KnSk_6	KnSk_5	KnSk_4	KnSk_3	KnSk_2	KnSk_1	Sp_3	Sp_2	Sp_1	KnSk_9	Contribution_3	Contribution_2	Contribution_1	Overall_2	Overall_1	QC_Comp	Tn_Acc	Tn_Sub
KnSk_8	.000																					
QC_Pres	1.119	.000																				
QC_Met	-1.113	-.366	.000																			
KnSk_7	2.254	.280	-.721	.000																		
KnSk_6	1.493	-.381	-2.308	.012	.000																	
KnSk_5	**2.943**	.183	-1.626	-.080	.061	.000																
KnSk_4	**2.701**	2.016	-.521	-.449	.347	1.135	.000															
KnSk_3	2.186	2.445	-1.204	2.464	.018	1.015	.824	.000														
KnSk_2	1.695	**3.075**	-.667	1.055	1.217	.610	-.006	-.100	.000													
KnSk_1	**2.685**	**2.932**	-1.151	.729	.870	-.077	-.569	-.365	.493	.000												
Sp_3	-1.350	**-2.624**	.473	-1.232	-1.827	-2.017	-.742	-1.515	-1.397	-.257	.000											
Sp_2	.435	-1.914	-.663	.065	-.204	-.838	-1.509	-1.916	-1.430	-.800	.582	.000										
Sp_1	-.822	-1.884	1.314	-1.170	-1.191	.115	-.288	-1.080	-.492	-.456	.319	-.190	.000									
KnSk_9	1.038	-.825	.771	2.546	2.012	2.148	1.974	1.583	-.366	1.391	1.361	2.553	2.341	.000								
Contribution_3	1.754	-2.123	-1.579	-1.586	-1.548	-.308	.778	-.614	-.476	1.612	2.495	1.710	1.934	.876	.000							
Contribution_2	1.262	.985	.452	-.681	-1.827	-.397	-.423	-.899	-2.502	-.153	.522	1.526	1.177	-1.531	-.566	.000						
Contribution_1	**2.797**	-.020	.292	-.599	-1.255	-.318	-.026	-.304	-1.145	.916	1.829	1.838	2.037	-.402	-.839	.885	.000					
Overall_2	1.278	-2.252	-.311	-.807	-.947	-.875	-1.168	-2.119	**-3.072**	-1.445	1.544	**2.642**	1.558	.216	1.142	-.127	-.174	.000				
Overall_1	1.461	-1.191	.522	-1.590	-1.177	-1.132	-1.411	-1.271	-2.403	-.010	1.645	**2.852**	2.229	-1.134	-.409	1.267	.436	-.036	.000			
QC_Comp	-1.096	2.520	**3.508**	-1.329	-.787	-.338	-.935	-1.337	-.128	-.211	-.433	-1.194	.921	1.037	-.078	.302	1.069	-1.162	.464	.000		
Tn_Acc	.096	-.025	-.877	.300	-1.288	.460	-1.490	-.905	.751	1.326	.060	-1.197	.118	.599	-.122	-.923	-.227	.393	-.238	.131	.000	
Tn_Sup	-.411	-1.035	.851	.578	-.977	.947	-.068	-.683	.060	.520	.363	-1.228	1.480	.561	-.549	-.097	-.765	.244	.307	-.260	.068	.000

Standardized Residual Covariances (Modified Model b)

	QC_Pres	QC_Met	KnSk_7	KnSk_6	KnSk_5	KnSk_4	KnSk_3	KnSk_2	KnSk_1	Sp_3	Sp_2	Sp_1	Contribution_3	Contribution_2	Contribution_1	Overall_2	Overall_1	QC_Comp	Tn_Acc	Tn_Sub
QC_Pres	.000																			
QC_Met	-.550	.000																		
KnSk_7	.043	-.636	.000																	
KnSk_6	-.624	-2.214	-.021	.000																
KnSk_5	-.073	-1.513	-.080	.083	.000															
KnSk_4	1.271	-.855	-.925	-.146	.613	.000														
KnSk_3	1.700	-1.564	1.939	-.508	.454	.815	.000													
KnSk_2	2.259	-1.091	.458	.602	-.036	-.120	-.305	.000												
KnSk_1	2.101	-1.507	.207	.335	-.629	-.430	-.345	.396	.000											
Sp_3	-2.426	1.123	-.186	-.730	-.814	.296	-.594	-.499	.931	.000										
Sp_2___35	-1.563	.193	1.336	1.133	.622	-.219	-.762	-.293	.675	.271	.000									
Sp_1___34	-1.615	2.037	-.088	-.051	1.377	.818	-.095	.477	.801	-.096	-.231	.000								
Contribution_3	-1.855	-.855	-.768	-.684	.650	1.534	.042	.152	2.484	.792	.079	.410	.000							
Contribution_2	1.121	1.034	.032	-1.079	.435	.168	-.391	-2.033	.528	-1.370	-.343	-.552	-.614	.000						
Contribution_1	.204	1.018	.249	-.363	.670	.716	.340	-.539	1.773	-.163	-.098	.232	-.716	.641	.000					
Overall_2	-2.023	.414	.037	-.056	.106	-.431	-1.481	-2.472	-.604	-.390	.741	-.190	1.299	-.332	-.206	.000				
Overall_1	-1.087	1.103	-.860	-.404	-.280	-.828	-.771	-1.944	.670	-.474	.746	.291	-.557	.747	.070	-.361	.000			
QC_Comp	2.391	3.775	-1.253	-.702	-.237	-1.174	-1.599	-.439	-.469	.076	-.524	1.486	.497	.762	1.644	-.594	.924	.000		
Tn_Acc	-.359	-.545	.246	-1.341	.409	-1.465	-.909	.718	1.364	-.089	-1.173	.080	.221	-.780	.039	.675	-.143	.414	.000	
Tn_Sub	-1.539	1.183	.478	-1.076	.847	-.074	-.724	-.020	.525	.102	-1.271	1.362	-.186	.012	-.509	.524	.348	.025	.043	.000

Published Paper

Ma, J., McGovern, T. and Hicks, C. (2010) 'Evaluating alternative approaches to Kaizen: a case of four Sino-Japanese joint ventures', *Sixteenth International Working Seminar on Production Economics.* Congress Innsbruck, Austria 03/2010.

Ma, J., Hicks, C. and McGovern, T. (2013) 'The role of *Teians* and QCCs in implementing *Kaizen*', *22nd International Conference on Production Research.* Foz do Iguaçu, Inguassu Falls, Brazil 28/07-01/08/2013.

Ma, J., McGovern, T. and Hicks, C. (2014) 'The impact of shop floor management tools on *Kaizen*: a study of lean implementation in Sino-Japanese automotive joint ventures', Abstract (103) accepted for *18th International Working Seminar on Production Economics*, Innsbruck, Austria, Feb 24-28, 2014 (Paper under peer review for International Journal of Production Economics Special Issues)

Bibliography

Abdi, H. (2004) 'Factor Rotations in Factor Analyses', in Lweis-Beck, M.S., Bryman, A. and Liao, T.F. (eds.) *the SAGE Encyclopedia of social Science Research Methods*. Thousand Oaks, California: SAGE publications Ltd., pp. 978-982.

Abdulmalek, F.A. and Rajgopal, J. (2007) 'Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study', *International Journal of Production Economics*, 107(1), pp. 223-236.

Adams, M., Componation, P., Czarnecki, H. and Schroer, B.J. (1999) *the 1999 Winter Simulation Conference*. Squaw Peak, Phoenix, AZ, . USA.

Aday, L.A. and Cornelius, L.J. (2006) *Designing and conducting health surveys*. Third Ediction edn. San Francisco, CA: John Wiley & Sons, Inc.

Agbejule, A. and Burrowes, A. (2007) 'Perceived environmental uncertainty, supply chain purchasing strategy, and use of MAS information: An empirical study of Finnish firms', *Managerial Auditing Journal*, 22(9), pp. 913-927.

Agus, A. (2011a) 'The Structural Influence of Supply Chain Management on Product Quality and Business Performance', *International Jounral of Trade, Economics and Finance*, 2(4), pp. 269-275.

Agus, A. (2011b) 'Supply chain management, supply chain flexibility and business performance', *Journal of Global Strategic Management*, 9, pp. 134-145.

Agus, A. and Hajinoor, M.S. (2012) 'Lean production supply chain management as driver towards enhancing product quality and business performance: case study of manufacturing companies in Malaysia', *International Jounral of Quality & Reliability Management*, 29(1), pp. 92-121.

Ahire, S.L. and Dreyfus, P. (2000) 'The impact of design management and process management on quality: an empirical investigation', *Journal of Operations Management*, 18(5), pp. 549-575.

Ahlstrom, P. (1998) 'Sequences in the implementation of lean production', *European Management Journal*, 16(3), pp. 327-334.

Ahlstrom, P. and Karlsson, C. (1996) 'Change processes towards lean production', *International Journal of Operations & Production Management*, 16(11), pp. 42-56.

Akaoka, I. (1983) 'Motivation of employees in Japan', *The Kyoto University Economic Review*, 53(1-2), pp. 25-50.

AL-Tahat, M.D. and Alkhalil, S.M. (2012) 'Evaluation and Analysis of Lean-Based Manufacturing Equipment and Technology System for Jordanian Industries', *World Academy of Science, Engineering and Technology*, 64, pp. 1192-1198.

AL-Tahat, M.D. and Bataineh, K.M. (2012) 'Statistical Analyses and Modeling of the Implementation of Agile Manufacturing Tactics in Industrial Firms', *Mathematical Problems in Engineering*, pp. 1-23.

Albaum, G. (1997) 'The Likert scale revisited: an alternative version', *Journal of the market research society* 39(2), pp. 331-348.

Aldridge, A. and Levine, K. (2001) *Surveying the social world*. Buckingham: Open University Press.

Alfnes, E. and Strandhagen, J.O. (2000) 'Enterprise Design for Mass Customisation: The Control Model Methodology', *International Journal of Logistics: Research & Applications*, 3(2), pp. 111-125.

Allen, R.S. and Kilmann, R.H. (2001) 'The role of the reward system for a total quality management based strategy ', *Journal of Organizational Change Management*, 14(2), pp. 110-131.

Allen, T.T. (2010) *Introduction to Engineering Statistics and Lean Sigma, Statistical Quality Control and Design of Experiments and Systems* Second Edition edn. New York: Springer.

Aloini, D., Martini, A. and Pellegrini, L. (2011) 'A structural equation model for continuous improvement: a test for capabilities, tools and performance', *Production Planning & Control*, 22(7), pp. 628-648.

Alreck, P. and Settle, R. (1985) *The Survey Research Handbook*. Homewood, IL: Richard D. Irwin Co.

Alukal, G. and Manos, A. (2006) *Lean Kaizen: A Simplified Approach to Process Improvements*. Milwaukee: American Society for Quality.

American Society for Quality (2012) *ASQ History*. Available at: http://asq.org/about-asq/who-we-are/history.html (Accessed: 01/10/2012).

American Society of Mechanical Engineers (2008) *Manufacturing time line*. Available at: http://www.asme.org/Communities/History/Resources/Manufacturing.cfm (Accessed: 24/08/2008).

Anderson-Connolly, R., Grunberg, L., Greenberg, E.S. and Moore, S. (2002) 'Is Lean Mean? : Workplace Transformation and Employee Well-being', *Work Employment Society*, 16, pp. 389-413.

Anderson, E.J. (1994) *The Management of Manufacturing, Models and Analysis*. Cambridge: Addison-Wesley Publishers.

Anderson, J.C. and Gerbing, D.W. (1988) 'Structural Equation Modeling in Practice: A Review and Recommended Two-Step Approach', *Psychological Bulletin*, 103(3), pp. 411-423.

Ansari, A. and Modarress, B. (1997) 'World-class strategies for safety: a Boeing approach', *International Journal of Operations & Production Management*, 17(3/4), pp. 389-398.

Aoki, K. (2008) 'Transferring Japanese kaizen activities to overseas plants in China', *International Journal of Operations & Production Management*, 28(6), pp. 518-539.

APICS - The Educational Society for Resource Management (1998) Falls Church: The Educational Society for Resource Management.

Arbuckle, J.L. (2006) *Amos 7.0 Programming Reference Guide*. U.S.: SPSS Inc.

Arbuckle, J.L. (2007) *Amos 16th user's guide*. Chicago: SPSS inc.

Armstrong, J.S. and Overton, T.S. (1977) 'Estimating Nonresponse Bias in Mail Surveys', *Journal of Marketing Research*, 14(3), pp. 396-402.

Arumugam, V., Chang, H.W., Ooi, K.-B. and Teh, P.-L. (2009) 'Self-assessment of TQM practices: a case analysis', *The TQM Journal*, 21(1), pp. 46-58.

Ary, D., Jacobs, L.C., Sorensen, C. and Razavieh, A. (2010) *Introduction to Research in Education*. 8 edition edn. Belmont, CA: Wadsworth, Cengage Learning.

Ashburn, A. (1977) 'Toyota's 'Famous Ohno System'', *American Machinist*, (July), pp. 120 -123.

Babbie, E. (2004) *The Practice of Social Research*. 10th edition edn. Belmont, CA, USA: Wadsworth/Thomson Learning.

Bacdayan, P. (2001) 'Quality improvement teams that stall due to poor project selection: An exploration of contributing factors', *Total Quality Management*, 12(5), pp. 589-598.

Bahri, S., Hamzah, D. and Yusuf, R.M. (2012) 'Implementation of Total Quality Management and Its Effect on Organizational Performance of Manufacturing Industries Through organizational Culture in South Sulawesi, Indonesia', *Journal of Business and Management*, 5(1), pp. 10-24.

Baides, N.R. and Moyano–Fuentes, J. (2012) 'The influence of the level of implementation of lean management on employees: an empirical study', *International Journal of Quality and Innovation*, 2(1), pp. 61-79.

Bakerjian, R. and Mitchell, P. (1993) *Tools and Manufacturing Engineers Handbook - VII - Continuous Improvement*. Fourth Edition edn. Dearborn, Michigan: Society of Manufacturing Engineers, One SME Drive.

Barclay, S., Todd, C., Finlay, I., Grande, G. and Wyatt, P. (2002) 'Not another questionnaire! Maximizing the response rate, predicting non-response and assessing non-response bias in postal questionnaire studies of GPs', *Family Practice*, 19(1), pp. 105-111.

Barkholz, D. and Bolduc, D.A. (2008) 'Denso rides Toyota, passes Bosch to become top supplier', *Automotive News Europe* (13 edn), 23/06/2008, pp. 22-22.

Barndorff-Nielsen, O. and Cox, D.R.R., David) (1989) *Asymptotic techniques for use in statistics*. London; New York: Chapman and Hall.

Bartezzaghi, E. (1999) 'The evolution of production models: is a new paradigm emerging?', *International Journal of Operations & Production Management*, 19(2), pp. 229-250.

Batchelor, R. (1994) *Henry Ford, mass production, modernism, and design*. Manchester: Manchester University Press.

Bateman, N. (2001) *Sustainability, a guide to process improvement*. Cardiff: Lean Enterprise Research Centre, Cardiff Business School.

Bateman, N. (2005) 'Sustainability: the elusive element of process improvement', *International Journal of Operations & Production Management*, 25(3), pp. 261-276.

Bateman, N. and Brander, C. (2000) 'The drive for process improvement', *Manufacturing Engineer*, 79(6), pp. 241-245.

Bateman, N. and David, A. (2002) 'Process improvement programmes: a model for assessing sustainability', *International Journal of Operations & Production Management*, 22(5), pp. 515-526.

Bateman, N. and Rich, N. (2003) 'Companies' perceptions of inhibitors and enablers for process improvement activities', *International Journal of Operations & Production Management*, 23(2), pp. 185-199.

Bayraktar, E., Jothishankar, M.C., Tatoglu, E. and Wu, T. (2007) 'Evolution of operations management: past, present and future', *Management Research News*, 30(11), pp. 843-871.

Becker, J.E. (2001) 'Implementing 5S to Promote Safety & Housekeeping', *Professional Safety*, 46(8), p. 29.

Bell, J. (2010) *Doing your research project*. Fifth Edition edn. Berkshire, England: Open University Press, McGraw-Hill Education.

Bentler, P. and Weeks, D. (1980) 'Linear structural equations with latent variables', *Psychometrika*, 45(3), pp. 289-308.

Bentler, P.M. (1988) 'Causal modeling via structural equation systems.', in Nesselroade, J.R. and Cattell, R.B. (eds.) *Handbook of multivariate experimental psychology*. New York: Plenum, pp. 317-335.

Bentler, P.M. (2005) *EQS 6 Structural equations program manual.* Encino, CA: Multivariate Software.

Bentler, P.M. and Wu, E.J.C. (2012) *EQS 6.1 for Windows User's Guide*. Multivariate Software, Inc.

Berger, A. (1997) 'Continuous improvement and kaizen: standardization and organizational designs', *Integrated Manufacturing Systems*, 8(2), pp. 110-117.

Bertrand, J.W.M. and Fransoo, J.C. (2002) 'Operations Management Research Methodologies using quantitative modeling', *International Journal of Operations & Production Management*, 22(2), pp. 241-264.

Bessant, J., Burnell, J., Harding, R. and Webb, S. (1993) 'Continuous improvement in British manufacturing', *Technovation*, 13(4), pp. 241-254.

Bessant, J. and Caffyn, S. (1997) 'High-involvement Innovation Through Continuous Improvement', *International Journal of Technology Management*, 14(1), pp. 7-28.

Bessant, J., Caffyn, S. and Gallagher, M. (2001) 'An evolutionary model of continuous improvement behaviour', *Technovation*, 21(2), pp. 67-77.

Bessant, J., Caffyn, S., Gilbert, J., Harding, R. and Webb, S. (1994) 'Rediscovering continuous improvement', *Technovation*, 14(1), pp. 17-29.

Bessant, J. and Francis, D. (1999) 'Developing strategic continuous improvement capability', *International Journal of Operations & Production Management*, 19(11), pp. 1106-1119.

Bessant, J., Lamming, R., Noke, H. and Phillips, W. (2005) 'Managing innovation beyond the steady state', *Technovation*, 25(12), pp. 1366-1376.

Bhuiyan, N. and Baghel, A. (2005) 'An overview of continuous improvement: from the past to the present', *Management Decision*, 43(5), pp. 761-771.

Bicheno, J. (1991) *Implementing JIT: How to Cut Out Waste and Delay in Any Manufacturing Operation*. Michigan, US: IFS Publications.

Bicheno, J. (2001) 'Kaizen and kaikaku', in Taylor, D. and Brunt, D. (eds.) *Manufacturing Operations and Supply Chain Management, the Lean approach*. Mitcham, Surrey: Thomson Learning, pp. 175-184.

Bicheno, J. (2004) *The new lean toolbox:Towards Fast, Flexible Flow* 2Rev Ed editopn edn. Picsie Books.

Bicheno, J. (2008) *The Lean Toolbox for Service Systems*. Buckingham, United Kingdom: Picsie Books.

Blair, E. and Zinkhan, G. (2006) 'Nonresponse and generalizability in academic research', *Journal of the Academy of Marketing Science*, 34(1), pp. 4-7.

Bodek, N. (2002) 'Quick and easy kaizen', *IIE Solutions*, 34(7), p. 43.

Bodek, N. (2004) *Kaikaku: The Power and Magic of Lean: a Study in Knowledge Transfer*. PCS Inc.

Bond, T.C. (1999) 'The role of performance measurement in continuous improvement', *International Journal of Operations & Production Management*, 19(12), pp. 1318-1334.

Bowden, S. and Higgins, D.M. (2004) 'British industry in the interwar years', in Floud, R. and Johnson, P. (eds.) *The Cambridge economic history of modern Britain*. Cambridge: Cambridge University Press, p. pp. 374.

Brown, R.V. (1969) 'Just How Credible Are Your Market Estimates?', *Journal of Marketing*, 33(3), pp. 46-50.

Browne, M.W. (1973) 'Generalized Least Squares Estimators in the Analysis of Covariance Structures', *South African Statistical Journal*, pp. 1-36.

Browning, T.R. and Heath, R.D. (2009) 'Reconceptualizing the effects of lean on production costs with evidence from the F-22 program', *Journal of Operations Management*, 27(1), pp. 23-44.

Bruin, J. (2006) *Annotated SPSS Output, Principal Components Analysis*. Available at: http://statistics.ats.ucla.edu/stat/spss/output/principal_components.htm (Accessed: 05/04/2013).

Brunet, A.P. and New, S. (2003) 'Kaizen in Japan: an empirical study', *International Journal of Operations & Production Management*, 23(12), pp. 1426-1446.

Bryman, A. (1992) *Research Methods And Organisation Studies*. London: Rouledge.

Bryman, A. (2004) *Social research methods*. Second Edition edn. Oxford, New York: Oxford University Press.

Buffa, E.S. (1980) 'Research in Operations Management', *Journal of Operations Management*, 1(1), pp. 1-7.

Buffa, E.S. and Sarin, R.K. (1987) *Modern Production/Operations Management*. Eighth edn. Singapore: John Wiley & Sons, Inc.

Burch, M.K. (2008) *Lean longevity: Kaizen events and determinants of sustainable improvement*. University of Massachusetts Amherst.

Burkell, J. (2003) 'The dilemma of survey nonresponse', *Library & Information Science Research*, 25(3), pp. 239-263.

Byrne, B.M. (2010) *Structural Equation Modeling with AMOS, Basic Concepts, Applications, and Programming*. Second Edition edn. London: Routledge.

Cabadas, J. (2004) *River Rouge: Ford's Industrial Colossus*. St. Paul,: MotorBooks International, an imprint of MBI Publishing Company.

Caffyn, S. (1999) 'Development of a continuous improvement self-assessment tool', *International Journal of Operations & Production Management*, 19(11), pp. 1138-1153.

Calantone, R.J. and Zhao, Y.S. (2001) 'Joint Ventures in China: A Comparative Study of Japanese, Korean, and U.S. Partners', *Journal of International Marketing*, 9(1), pp. 1-23.

Carroll, J. (1953) 'An analytical solution for approximating simple structure in factor analysis', *Psychometrika*, 18(1), pp. 23-38.

Cattell, R.B. (1966) 'The screen test for the number of factors', *Multivariate Behavioral Research*, 1(2), pp. 245-276.

Charantimath, P.M. (2003) *Total Quality Managent*. Singapore: Pearson Education India, Dorling Kindersley (India) Pvt. Ltd.

Charles, A.A. and Chucks, O.K. (2012) 'Adopting the Kaizen Suggestion System in South African Lean Automotive Components Companies', *Science Journal of Microbiology*, 2012, p. 10.

Chartered Quality Institute (2011) *Continual Improvement*. Available at: http://www.thecqi.org/Knowledge-Hub/Resources/Factsheets/Continual-improvement/ (Accessed: 21/01/2011).

Chen, J., Lee, C. and Fujimoto, T. (1997) *Adaptation of Lean Production in China: The Impact of the Japanese Management Practice*. Working Paper for MIT IMVP. Faculty of Economics, University of Tokyo.

Chen, J., Pu, X. and Shen, H. (2008) 'A Comprehensive Model of Technological Learning: Empirical Research on Chinese Manufacturing Sector', *Journal of Business and Management*, 5(1), pp. 10-24.

Chen, J.C., Li, Y. and Shady, B.D. (2010) 'From value stream mapping toward a lean/sigma continuous improvement process: an industrial case study', *International Journal of Production Research*, 4(15), pp. 1069-1086.

Chettiar, R.M.V., Fallah, A. and Mehrizi, A.A.H. (2012) *International Quality Conference*. Center for Quality, Faculty of Engineering, University of Kragujevac, June 08th 2012.

Chevedden, J. and Kowalke, R. (2012) *Standard Catalog of Oldsmobile, 1897-1997*. Iola: Krause Publications.

Chin, G.T. (2010) *China's Automotive Modernization : The Party-state and Multinational Corporations*. US: Palgrave Macmillan Ltd. .

Chin, W.W. (1998) 'The partial least squares approach to structural equation modeling', in Marcoulides, G.A. (ed.) *Modern Methods for Business Research*. Taylor & Francis, pp. 295-336.

China Automotive Industry Yearbook (2011) *中国汽车工业年鉴*.China Automotive Technology & Research Center (中国汽车技术研究中心).

Chinese State Council (2010) *China Automobile Industry*. Available at: http://www.chinaknowledge.com/Chinese/ (Accessed: 19/03/2010).

Choi, T. (1995) 'Conceptualizing continuous improvement: Implications for organizational change', *Omega*, 23(6), pp. 607-624.

Choi, T.Y. and Liker, J.K. (1995) 'Bringing Japanese Continuous Improvement Approaches to U.S. Manufacturing: The Roles of Process Orientation and Communications', *Decision Sciences*, 26(5), pp. 589-620.

Chong, H., White, R.E. and Prybutok, V. (2001) 'Relationship among organizational support, JIT implementation, and performance', *Industrial Management & Data Systems*, 101(6), pp. 273-281.

Chou, C.-P. and Bentler, P.M. (1990) 'Model Modification in Covariance Structure Modeling: A Comparison among Likelihood Ratio, Lagrange Multiplier, and Wald Tests', *Multivariate Behavioral Research*, 25(1), pp. 115-136.

Choudri, A. (2002) 'Lean Manufacturing', in ReVelle, J.B. (ed.) *Manufacturing Handbook of Best Practices, An innovation, productivity, and quality focus*. Boca Ratonm, London, New York, Washington, D.C.: CRC Press, pp. 169-202.

CINet (2002) *CINET Survey*.

Clark, H. and Brody, D. (2009) *Design studies: a reader*. Oxford: Berg.

Clarke, C. (2005) *Automotive production systems and standardisation: from Ford to the case of Mercedes-Benz*. Heilbronn: Physica-Verlag.

Coakes, S.J. (2005) *SPSS Analysis without Anguish: version 12.0 for Windows*. Milton: John Wiley & Sons Australia, Ltd.

Cohen, J. (1988) *Statistical power analysis for the behavioral sciences*. Second Edition edn. New Jersey: Lawrence Erlbaum Associates, Inc.

Cohen, S.G. and Bailey, D.E. (1997) 'What Makes Teams Work: Group Effectiveness Research from the Shop Floor to the Executive Suite', *Jounral of Management* 23(3), pp. 239-290.

Coleman, W.E. (1993a) 'Kaizen Teian 1: Developing Systems for Continuous Improvement Through Employee Suggestions', *Personnel Psychology*, 46(2), pp. 426-428.

Coleman, W.E. (1993b) 'Kaizen Teian 2: Guiding Continuous Improvement Through Employee Suggestions', *Personnel Psychology*, 46(2), pp. 428-430.

Colledani, M., Ekvall, M., Lundholm, T., Moriggi, P., Polato, A. and Tolio, T. (2010) 'Analytical methods to support continuous improvements at Scania', *International Journal of Production Research*, 48(7), pp. 1913-1945.

Collins, T. (2007) *The Legendary Model T Ford: The Ultimate History of America's First Great Automobile*. Iola: Krause Publications.

Cooper, D.R. and Schindler, P.S. (2003) *Business Research Method*. Eighth Edition edn. New York: McGraw-Hill Higher Education.

Corbetta, P. (2003) *Social Research: Theory, Methods and Techniques*. London: SAGE Publications Ltd.

Corsten, D. and Felde, J. (2005) 'Exploring the performance effects of key-supplier, An empirical investigation into Swiss buyer-suppler relationships', *International Journal of Physical Distribution & Logistics Management*, 35(6), pp. 445-461.

Cousins, P.D. and Lawson, B. (2007) 'Sourcing Strategy, Supplier Relationships and Firm Performance: An Empirical Investigation of UK Organizations', *British Journal of Management*, 18(2), pp. 123-137.

Craighead, C.W. and Meredith, J.R. (2008) 'Operations management research: evolution and alternative future paths', *International Jounral of Operations & Production Management*, 28(8), pp. 710-726.

Crocker, O.L., Chiu, J.S.L. and Charney, C. (1984) *Quality Circles: A guide to participation and productivity*. 1984 edn. Toronto, New York, London, Sydney, Auckland: Methuen Publications.

Cronbach, L. (1951) 'Coefficient alpha and the internal structure of tests', *Psychometrika*, 16(3), pp. 297-334.

Croom, S. (2009) 'Introduction to Research Methodology in Operations Manageemnt', in Karlsson, C. (ed.) *Researching Operations Management*. New York and London: Routledge, pp. 42-83.

Cunningham, E.G. and Wang, W.C. (2005) *IASE Satellite Conference on Statistics Education and the Communication of Statistics*. Sydney. Australia.

Cusumano, M.A. (1988) 'Manufacturing Innovation: Lessons from the Japanese Auto Industry', *Sloan Management Review*, 30(1), pp. 29-39.

Cusumano, M.A. and Takeishi, A. (1991) 'Supplier Relations and Management: A Survey of Japanese, Japanese- Transplant, and U.S. Auto Plants', *Strategic Management Journal*, 12(8), pp. 563-588.

Dahlgaard-Park, S.M. (2009) 'Towards a human-oriented metrology for improvement and change', *Measuring Business Excellence*, 13(1), pp. 3-22.

Dal Pont, G., Furlan, A. and Vinelli, A. (2008) 'Interrelationships among lean bundles and their effects on operational performance', *Operations Management Research*, 2008(1), pp. 150-158.

Dale, B.G. (1996) 'Sustaining a process of continuous improvement: definition and key factors', *TQM magazine*, 8(2), 1996, pp. 49-41.

Daniel, S.J., Lee, D., Reitsperger, W.D. and Morsed, K. (2010) 'Implementation of Japanese manufacturing strategies through management control systems', *Asian Business & Management* 10, pp. 37-65.

Datta, S. (2004) 'Adaptive Value Networks: Convergence of Emerging Tools, Technologies and Standards as Catalytic Drivers', in *Evolution of Supply Chain Management: Symbiosis of Adaptive Value Networks and ICT*. Kluwer Academic Publishers.

De Jager, B., Minnie, C., de Jager, J., Welgemoed, M., Bessant, J. and Francis, D. (2004) 'Enabling continuous improvement: a case study of implementation', *Journal of Manufacturing Technology Management*, 15(4), pp. 315-324.

De Mente, B.L. (1976) *Cultural Failures That Are Destroying the American Dream! - The Destructive Influence of Male Dominance & Religious Dogma!* Phoenix Books. Available at: http://www.amazon.co.uk/DESTROYING-Destructive-Influence-Dominance-ebook/dp/B004GEAPTW (Accessed: 01/10/2012).

De Treville, S., Antonakis, J. and Edelson, N.M. (2005) 'Can standard operating procedures be motivating? Reconciling process variability issues and behavioural outcomes1', *Total Quality Management & Business Excellence*, 16(2), pp. 231-241.

De Vaus, D.A. (2002) *Surveys in Social Research*. Australia: Routledge.

de Winter, A.F., Oldehinkel, A.J., Veenstra, R., Brunnekreef, J.A., Verhulst, F. and Ormel, J. (2005) 'Evaluation of non-response bias in mental health determinants and outcomes in a large sample of pre-adolescents', *European Journal of Epidemiology*, 20(2), pp. 173-181.

DeCarlo, L.T. (1997) 'On the Meaning and Use of Kurtosis', *Psychological Methods*, 2(3), pp. 292-307.

Delbridge, R., Lowe, J. and Oliver, N. (1995) 'The process of benchmarking, a study from the automotive industry', *international Journal of Operations & Production Management*, 15(4), pp. 50-62.

Delbridge, R., Lowe, J. and Oliver, N. (2000) 'Shopfloor responsibilities under lean teamworking', *Human Relations*, 53(11), pp. 1459-1479.

Deming, W.E. (1950) 'Deming's 1950 Lecture to Japanese Management', *Lecturer and Meetings*. Available at: http://hclectures.blogspot.co.uk/1970/08/demings-1950-lecture-to-japanese.html.

Deming, W.E. (1982) *Quality, productivity, and competitive position*. Massachusetts Institute of Technology, Center for Advanced Engineering Study.

Deming, W.E. (1986) *Out of the Crisis: Quality, Productivity and Competitive Position*. Cambridge University Press.

Dennis, P. and Shook, J. (2007) *Lean Production Simplified, A Plain-Language Guide to the World's Most Powerful Production System* second edition edn. Productivity Press.

Denton, K. (1995) 'Creating a system for continuous improvement', *Business Horizons*, 38(1), p. 16.

Dertouzos, M.L., Lester, R.K. and Solow, R.M. (1989) *Made in America: Regaining the productive edge*. Cambridge, MA: MIT Press.

Detty, R.B. and Yingling, J.C. (2000) 'Quantifying benefits of conversion to lean manufacturing with discrete event simulation: a case study', *International Journal of Production Research*, 38(2), pp. 429-445.

DiBarra, C. (2002) '5S—A Tool for Culture Change in Shipyards ', *Journal of Ship Production*, 18(3), pp. 143-151.

Dinero, D.A. (2005) *Training Within Industry: The Foundation Of Lean*. New York, NY: Productivity Press.

Ding, L., Velicer, W.F. and Harlow, L.L. (1995) 'Effects of estimation methods, number of indicators per factor, and improper solutions on structural equation modeling fit indices', *Structural Equation Modeling: A Multidisciplinary Journal*, 2(2), pp. 119-143.

Dino, A. (2009) 'Implementing Horn's parallel analysis for principal component analysis and factor analysis', *The stata journal*, 9(2), pp. 291-298.

Doolen, T.L., Van Aken, E.M., Farris, J.A., Worley, J.M. and Huwe, J. (2008) 'Kaizen events and organizational performance: a field study', *International Journal of Productivity and Performance Management*, 57(8), pp. 637-658.

Doolen, T.L., Worley, J., Van Aken, E.M. and Farris, J. (2003) *Proceedings of the 2003 Industrial Engineering and Research Conference*. Portland, May 18-20. OR.

Dossenbach, T. (2006a) 'INCREASING PRODUCTIVITY AND PROFITS THROUGH 5-S', *Wood & Wood Products*, 111(3), pp. 29-32.

Dossenbach, T. (2006b) 'Increasing Productivity and Profits Through 5-S', *Wood & Wood Products*, 111(5), pp. 33-38.

Duggan, K.J. (2002) *Creating Mixed Model Value Streams*. Productivity Press.

Eckermann, E. and Albrecht, P.L. (2001) *World History of the Automobile* Translated by Albrecht, P.L. SAE.

Eckhardt, B. (2001) 'The 5-S housekeeping program aids production', *Concrete Products*, 104(11), p. 56.

Eckhardt, R. (1987) 'Stan Ulam, John von Neumann, and the Monte Carlo Method', *Los Alamos Science*, Special Issue pp. 131-143.

Efron, B. (1979) 'Bootstrap Methods: Another Look at the Jackknife', *The Annals of Statistics*, 7(1), pp. 1-26.

Efron, B. (1982) *The Jackknife, the Bootstrap, and other Resampling Plans*. Philadelphia: SIAM.

Efron, B. and Tibshirani, R. (1993) *An introduction to the bootstrap*. London: Chapman & Hall.

Eisenhardt, K.M. (1989) 'Building Theories from Case Study Research', *The Academy of Management Review*, 14(4), pp. 532-550.

Elger, T. and Smith, C. (1994) *Global Japanization?: the transnational transformation of the labour process*. London: Routledge.

Emiliani, M.L. (2006) 'Origins of lean management in America', *Journal of Management History*, 12(2), pp. 167-184.

Emiliani, M.L. and Stec, D.J. (2004) 'Using Value-Stream Maps to Improve Leadership', *Leadership & Organization Development Jounral*, 25(8), pp. 622-645.

Emory, W. and Cooper, D.R. (1991) *Business research methods*. 4 edn. McGraw-Hill Education.

Encyclopaedia Britannica, i. (1998) *The New Encyclopaedia Britannica*. (29 vols). London: Encyclopædia Britannica (UK) Limited.

Engström, T., Jonsson, D. and Medbo, L. (1996) 'Production model discourse and experiences from the Swedish automotive industry', *International Journal of Operations & Production Management*, 16(2), pp. 141-158.

Evans, J.R. (1993) *Applied Production and Operations Management*. Fourth Edition edn. St. Paul MN: West Publishing Company.

Evans, J.R., Anderson, D.R., Sweeney, D.J. and Williams, T., A. (1990) *Applied Production & Operations Management* Third Edition edn. St. Paul: West Publishing Company.

Fadlelmula, F.K. (2011) 'Assessing power of structural equation modeling studies: a meta-analysis', *Education Research Journal* 1(3), pp. 37-42.

Fairbank, J.F. and Williams, S.D. (2001) 'Motivating Creativity and Enhancing Innovation through Employee Suggestion System Technology', *Creativity & Innovation Management*, 10(2), p. 68.

Farahani, R.Z., Rezapour, S. and Kardar, L. (2011) *Logistics Operations and Management: Concepts and Models*. London: Elsevier.

Farris, J.A. (2006) *An Empirical Investigation of Kaizen Effectiveness: Outcomes and Critical Success Factors*. Virginia Polytechnic Institute and State University.

Farris, J.A., Van Aken, E.M., Doolen, T.L. and Worley, J. (2008) 'Learning From Less Successful Kaizen Events: A Case Study', *Engineering Management Journal*, 20(3), pp. 10-20.

Farris, J.A., Van Aken, E.M., Doolen, T.L. and Worley, J. (2009) 'Critical success factors for human resource outcomes in Kaizen events: An empirical study', *International Journal of Production Economics*, 117(1), pp. 42-65.

Feld, W.M. (2001) *Lean Manufacturing, Tools, Techniques, and How to Use Them*. Boca Raton, Florida: The CRC Press Series on Resource Management.

Field, A. (2005) *Discovering Statistics Using SPSS*. Third Edition edn. London: Sage.

Filippini, R. (1997) 'Operations management research: some reflections on evolution, models and empirical studies in OM', *International Journal of Operations & Production Management*, 17(7), pp. 655-670.

Fisher, M. (2007) 'Strengthening the empirical base of operations management', *Manufacturing & Service Operations Management*, 9(4), pp. 368-382.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A. and Flynn, E.J. (1990) 'Empirical research methods in operations management', *Journal of Operations Management*, 9(2), pp. 250-284.

Ford, H. (1926) *Today and Tomorrow*. Reprint Edition edn. Cambridge, Massachusetts: Productivity Press.

Forza, C. (2002) 'Survey research in operations management: a process-based perspective', *International Journal of Operations & Production Management*, 22(2), pp. 152-194.

Forza, C. and Salvador, F. (2001) 'Information flows for high-performance manufacturing', *International Journal of Production Economics*, 70(1), pp. 21-36.

Fotopoulos, C.B. and Psomas, E.L. (2009) 'The impact of “soft” and “hard” TQM elements on quality management results', *International Journal of Quality & Reliability Management*, 26(2), pp. 150-163.

Fowler, F.J.J. (1995) *Improving Survey Questions, Design and evalution*. Thousand Oads, London and New Delhi: SAGE Publications.

Fowler, F.J.J. (2002) *Survey Research Methods*. London, UK: Sage Publications, Inc,.

Freire, J. and Alarco´n, L.F. (2002) 'Achieving Lean Design Process: Improvement Methodology', *Journal of Construction Engineering & Management*, 128(3), p. 248.

Frese, M., Teng, E. and Wijnen, C.J.D. (1999) 'Helping to improve suggestion systems: predictors of making suggestions in companies', *Journal of Organizational Behavior*, 20(7), pp. 1139-1155.

Friedland, J. (2012) *The Acceleration Of China's Auto Industry Leads To Opportunities For Investors*. Available at: http://seekingalpha.com/article/1057031-the-acceleration-of-china-s-auto-industry-leads-to-opportunities-for-investors (Accessed: 12/11/2012).

Fujimoto, T. (1999) *Evolution of Manufacturing Systems at Toyota*. Oxford, New York: Oxford University Press US.

Fujimoto, T. and Takeishi, A. (2001) *Automoblies: Strategy-Based Lean Production System*.

Fukui, R., Honda, Y., Inoue, H., Kaneko, N., Miyauchi, I., Soriano, S. and Yagi, Y. (2003) *Handbook for TQM and QCC*. Inter-American Development Bank.

Fullerton, R.R., Kennedy, F.A. and Widener, S.K. (2012) 'Management accounting and control practices in lean manufacturing environment', *Accounting, Organizations and Society*, 10(001).

Fullerton, R.R. and McWatters, C.S. (2001) 'The production performance benefits from JIT implementation', *Journal of Operations Management*, 19(1), pp. 81-96.

Fullerton, R.R. and Wempe, W.F. (2005) *Financial Consequences from Implementing Lean Manufacturing with the Support of Non-Financial Management Accounting Practices*. Available at: SSRN: http://ssrn.com/abstract=773645 or http://dx.doi.org/10.2139/ssrn.773645 (Accessed: 01/05/2013).

Fullerton, R.R. and Wempe, W.F. (2009) 'Lean manufacturing, non-financial performance measures, and financial performance', *International Jounral of Operations & Production Management*, 29(3), pp. 214-240.

Fynes, B., Voss, C. and de Burca, S. (2005) 'The impact of supply chain relationship quality on quality performance', *International Journal of Production Economics*, pp. 339-354.

Gabriel, V.A. (2003) *Management*. Singapore: Pearson Education South Asia Pte Ltd.

GAC-Toyota (2008) *TL Role, TL de zhize, zhiwu* Training material. GAC-Toyota.

Gapp, R., Fisher, R. and Kobayashi, K. (2008) 'Implementing 5S within a Japanese context: an integrated management system', *Management Decision*, 46(4), pp. 565-579.

Garver, M.S. and Mentzer, J.T. (1999) 'Logistics research methods: employing structural equation modelling to test for construct validity', *Journal of Business Logistics*, 20(1), pp. 33-57.

Gaskin, J. (2011) *Exploratory Factor Analysis*. Available at: http://statwiki.kolobkreations.com/wiki/Exploratory_Factor_Analysis#Factor_Structure (Accessed: 03/03/2013).

Gåsvaer, D. and von Axelson, J. (2012) 'Kaikaku - Radical Improvement in Production', *World Academy of Science, Engineering and Technology*. 09/2012. pp. 758-765.

Ghalayini, A.M., Noble, J.S. and Crowe, T.J. (1997) 'An integrated dynamic performance measurement system for improving manufacturing competitiveness', *International Journal of Production Economics*, 48(3), pp. 207-225.

Ghosh, B.C. and Song, L.K. (1991) 'Structures and Processes of Company Quality Control Circles (QCCs): An Explanatory Study of Japan, the USA and Singapore', *Management Decision*, 29(7), pp. 45-53.

Gilbreth, F.B. and Carey, E.G. (1948) *Cheaper by the dozen*. New York: HarperCollins.

Gill, J. and Johnson, P. (2010) *Research Methods for Managers*. 4th edn. London: SAGE Publications Ltd.

Gimenez, C. (2005) 'Case Studies and Surveys in Supply Chain Management Research — Two Complementary Methodologies', in Kotzab, H., Seuring, S., Müller, M. and Reiner, G. (eds.) *Research Methodologies in Supply Chain Management*. Physica-Verlag HD, pp. 315-330.

Glover, W.J. (2010) *Critical Success Factors for Sustaining Kaizen Event Outcomes*. Virginia Polytechnic Institute and State University.

Gotō, A. and Odagiri, H. (1997) *Innovation in Japan*. Oxford: Oxford University Press.

Graban, M. and Swartz, J.E. (2012) *Healthcare Kaizen: Engaging Front-Line Staff in Sustainable Continuous Improvements*. Taylor & Francis.

Grace, J.B. (2012) *Structrual equation modeling essentials*. Available at: http://www.structuralequations.com/siteinfo.html (Accessed: 01/10/2012).

Graham, L. (1995) *On the line at Subaru-Isuzu: the Japanese model and the American worker*. New York: ILR Press & Cornell University Press.

Granger, C. (1993) 'Nissan stays in the driving seat', *Machinery and Production Engineering*, 151(3834), pp. 50-52.

Gravetter, F.J. and Wallnau, L.B. (2009) *Statistics for the behavioral sciences*. 8 edition edn. Belmont, CA: Wadsworth Cengage Learning.

Greenbaum, H.H., Kaplan, I.T. and Metlay, W. (1988) 'Evaluation of Problem-Solving Groups: The Case of Quality Circle Programs', *Group & Organization Management*, 13(2), pp. 133-147.

GRIPS, D.F. (2009) *Introducing Kaizen in Africa*. National Graduate Institute for Policy Studies. Available at: http://www.grips.ac.jp/forum-e/ (Accessed: 26/12/2012).

Gupta, M.C. and Boyd, L.H. (2008) 'Theory of constraints: a theory for operations management', *International Journal of Operations & Production Management*, 28(10), pp. 991-1012.

Gupta, S., Verma, R. and Victorino, L. (2006) 'Empirical Research Published in Production and Operations Management (1992–2005): Trends and Future Research Directions', *Production and Operations Management*, 15(3), pp. 432-448.

Habidin, N.F., Zubir, A.F.M., Conding, J., Jaya, N.A.S.L. and Hasbim, S. (2012) 'the development of sustaining lean improvements and sustainable performance in Malaysian autommotive industry', *International Journal of Lean Thinking* 3(2), pp. 79-90.

Hair, J.F., Ringle, C.M. and Sarstedt, M. (2011) 'PLS-SEM: Indeed a Silver Bullet', *Journal of Marketing Theory & Practice*, 19(2), pp. 139-151.

Hair, J.F.J., Black, W.C., Babin, B.J. and Anderson, R.E. (2010) *Multivariate data analysis*. Seventh Edition edn. Upper Saddle River: Prentice Hall.

Hallgren, M. and Olhager, J. (2009) 'Lean and agile manufacturing: external and internal drivers and performance outcomesI', *International Journal of Operations & Production Management*, 29(10), pp. 976-999.

Hallihan, A., Sackett, P. and Williams, G.M. (1997) 'JIT manufacturing:the evolution to animplementation model founded in current practice', *International Journal of Production Research*, 35(4), pp. 901-920.

Handyside, E. (1997) *Genba Kanri*. Hampshire, Brookfield: Gower Publishing Limited.

Harrington, H.J. (1995) 'Continuous Versus breakthrough improvement: Finding the Right Answer', *Business Process Re-engineering & Management Journal*, 1(3), pp. 31-49.

Harrington, H.J. (2006) *Process management excellence: the art of excelling in process management*. Chico: Paton Press LLC.

Harrison, A. (2002) 'Case Study Research', in Partington, D. (ed.) *Essential Skills for Management Research*. London: SAGE Publications Ltd, pp. 158-180.

Harwit, E. (1995) *China's Automobile Industry: Policies, Problems, and Prospects*. USA: M.E. Sharpe, Inc.

Hashim, S., Zubir, A.F.M., Conding, J., Jaya, N.A.S.L. and Habidin, N.F. (2012) 'Kaizen Event and Innovation Performance in Malaysian Automotive Industry', *Business Management and Strategy*, 3(2), pp. 11-22.

Hatcher, L. (1994) *A Step-by-Step Approach to Using the SAS® System for Factor Analysis and Structural Equation Modeling*. Cary, NC:: SAS Institute, Inc.

Hayes, B.E. (2008) *Measuring customer satisfaction and loyalty: survey design, use, and statistical analysis methods*. Third Edition edn. Milwaukee: American Society for Quality, Quality Press.

Hayes, R.H. (1981) 'Why Japanese factories work', *Harvard Business Review*, 59(4), pp. 56-66.

Hayes, R.H. and Wheelwright, S.C. (1984) *Restoring Our Competitive Edge: Competing Through Manufacturing*. New York: Wiley.

Hemmant, R. (2007) 'The 5Ss To Keeping Lean on Course', *Circuits Assembly* (18 edn), pp. 30-30. [Online] Available at: http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=26134479&site=ehost-live
Henriques, J.B. (2011) *Factor analysis versus PCA*. Available at: http://psych.wisc.edu/henriques/pca.html (Accessed: 04/05/2013).

Hensley, R.L. (1999) 'A review of operations management studies using scale development techniques', *Journal of Operations Management*, 17(3), pp. 343-358.

Herron, C. (2006) *A methodology to disseminate selected Lean Manufacturing tools into general manufacturing* Newcastle University.

Herron, C. (2007) 'Lean or flabby? [Lean Overview]', *Manufacturing Engineer*, 86(5), 12/12/2007, pp. 36-39.

Herron, C. and Braiden, P.M. (2007) *Agile Manufacturing, 2007. ICAM 2007. IET International Conference*. .

Herron, C. and Hicks, C. (2008) 'The transfer of selected lean manufacturing techniques from Japanese automotive manufacturing into general manufacturing (UK) through change agents', *Robotics and Computer-Integrated Manufacturing*, 24(4), pp. 524-531.

Hershberger, S.L. (2003) 'The growth of Structural Equation Modeling :1994-2001', *Structural Equation Modeling: A Multidisciplinary Journal*, 10(1), pp. 35-46.

Hicks, C. (2007) *Operations Management, 20/11/2007*.

Hill, A.V. (2012) 'The Encyclopedia of Operations Management', in. New Jersey: Pearson Education, Inc., p. pp. 400.

Hill, T. (2000) *Operations Management*. New York: Palgrave.

Hines, P., Found, P., Griffiths, G. and Harrison, R. (2008) *Staying Lean, Thriving, not just serviving*. Cadiff: Lean Enterprise Research Centre.

Hines, P., Holweg, M. and Rich, N. (2004) 'Learning to evolve, a review of contemporary lean thinking', *International Journal of Operations & Production Management*, 24(10), pp. 994-1011.

Hines, P. and Rich, N. (1997) 'The seven value stream mapping tools', *International Journal of Operations & Production Management*, 17(1), pp. 46-64.

Hines, P. and Rich, N. (2001) 'The seven value stream mapping tools', in Taylor, D. and Brunt, D. (eds.) *Manufacturing Operations and Supply Chain Management, the Lean approach*. Mitcham, Surrey: Thomson Learning, pp. 27-43.

Hines, P. and Taylor, D. (2000) *Going Lean: a guide to implementation*. Cardiff: Lean Enterprise Research Centre.

Hino, S. (2006) *Inside the mind of Toyota, Management principles for enduring growth*. English edn. Translated by Dillon, A.P. New York: Productivity Press.

Hirano, H. (1988) *JIT Factory Revolution, a Pictorial Guide to Factory Design of the Future*. English edn. Translated by Black, J.T. Cambridge, Ma: Productivity Press.

Hirano, H. (1990) *5 Pillars of the visual workplace: the sourcebook for 5S implementation*. USA: Productivity Press, Inc.

Hirano, H. (1993) *Putting 5S to Work: a Practical Step-by-Step Approach*. English Translation edn. Tokyo, kyoto, New York, Singapore: PHP Institute Inc.

Hirano, H. (1996) *5S for Operators: 5 Pillars of the Visual Workplace*. Portland, Oregon: Productivity Press.

Ho, S.K. and Cicmil, S. (1996) 'Japanese 5-S practice', *The TQM Magazine*, 8(1), pp. 45-53.

Ho, S.K., Cicmil, S. and Fung, C.K. (1995) 'The Japanese 5-S practice and TQM training', *Training for Quality*, 3(4), pp. 19-24.

Ho, S.K.M. (1997) 'Workplace learning: the 5-S way', *Journal of Workplace Learning*, 9(6), pp. 185-191.

Ho, s.K.M. (1998) '5-S practice: a new tool for industrial management', *Industrial Management & Data Systems*, 98(2), pp. 55-62.

Ho, S.K.M. (1999) *Operations and Quality Management*. London: International Thompson Business Press.

Hoang, D.T., Igel, B. and Laosirihongthong, T. (2006) 'The impact of total quality management on innovation: Findings from a developing country', *International Journal of Quality & Reliability Management*, 23(9), p. 1092.

Hobbs, D.P. (2004) *Lean Manufacturing Implementation, A Complete Excution Manual for Any Size Manufacturer*. U.S.A.: J. Ross Publishing, Inc.

Hoe, S.L. (2008) 'Issues and procedures in adopting structural equation modeling technique', *Journal of applied quantitative methods*, 3(1), pp. 76-83.

Hofstede, G. (1998) 'Attitudes, Values and Organizational Culture: Disentangling the Concepts', *Organization Studies*, 19(3), pp. 477-493.

Holweg, M. (2007) 'The genealogy of lean production', *Journal of Operations Management*, 25(2), pp. 420-437.

Honda Motor (1998) *NH Circle Pocketbook A6*. UK: Honda Motor Europe Ltd.

Hong, P. and Rawski, G. (2012) 'Benchmarking sustainability practices: evidence from manufacturing firms', *Benchmarking: An International Jounral*, 19(4/5), pp. 634-648.

Horn, J.L. (1965) 'A rationale and test for the number of factors in factor analysis', *Psychometrika*, 30(2), pp. 179-185.

Hotelling, H. (1933) 'Analysis of complex of statistical variables into principal components', *Journal of Education Psychology*, 24(6), pp. 417-441.

Howard, M. (2005) 'Collaboration and the '3DayCar': a study of automotive ICT adoption', *Journal of Information Technology (Palgrave Macmillan)*, 20(4), pp. 245-258.

Hox, J.J. (1995) 'AMOS, EQS, and LISREL for windows: a comparative review', *Structural Equation Modeling: A Multidisciplinary Journal*, 2(1), pp. 79-91.

Hoyle, R.H. (1995) 'Structural equation modeling approach: basic concepts and fundamental issues.', in Hoyle, R.H. (ed.) *Structural equation modeling: Concepts, issues, and applications*. Thousand Oaks, CA: SAGE, pp. 1-15.

Huda, F. (1992) *Kaizen, The understanding and application of continuous improvement*. Cheltenham: Technical Communications (Publishing) Ltd.

Hull, F., Azumi, K. and Wharton, R. (1988) 'Suggestion Rates and Sociotechnical Systems in Japanese versus American Factories : Beyond Quality Circles', *IEEE Transactions on Engineering Management*, 35(1), pp. 11-24.

Hult, G.T.M., Ketchen, D.J., Cui, A.S., Prud'homme, A.M., Seggie, S.H., Stanko, M.A., Xu, A.S. and Cavusgil, S.T. (2006) 'An Assessment of the Use of Structural Equation Modeling in International Business Research', *Research Methodology in Strategy and Management*, 3, pp. 385-415.

Hyland, P., Mellor, R., O'Mara, E. and Kondepudi, R. (2000) 'A comparison of Australian firms and their use of continuous improvement tools', *The TQM Magazine*, 12(2), pp. 117-124.

IBM (2010) *IBM SPSS Statistics 19 Brief Guide*. online: IBM Company.

IBM (2011) *SPSS Amos Features and benefits*. Available at: http://www-01.ibm.com/software/analytics/spss/products/statistics/amos/features.html (Accessed: 01/11/2011).

Ichikawa, M. and Konishi, S. (1995) 'Application of the bootstrap methods in factor analysis', *Psychometrika*, 60(1), pp. 77-93.

IEE (1997) *IEE Breakfast Colloquium*. 1997. the IEE.

Iguchi, H. (2003) *Unfinished Business: Ayukawa Yoshisuke and U.S.-Japan Relations, 1937-1953*. America: President and Fellows of Harvard College.

Imai, M. (1986) *Kaizen, The Key to Japan's Competitive Success*. 1st edn. United States of America: McGraw-Hill, Inc.

Imai, M. (1997) *Gemba Kaizen: A Commonsense, Low-cost Approach to Management*. McGraw-Hill Professional.

IMVP (2008) *IMVP History*. Available at: http://www.imvpnet.org/about.asp (Accessed: 10/09/2008).

Industrial Engineer (2008) 'Lean reaches rural hospital', *Industrial Engineer: IE*, 40(2), pp. 48-48.

Industry Forum (2008) *the Common Approach Toolkit*. Available at: http://www.industryforum.co.uk/products/common.shtml#common (Accessed: 31/08/3008).

Inoue, K. (1985) *The Education and Training of Industrial Manpower in Japan*. Washington The International Bank for Reconstruction and Development/THE WORLD BANK.

Isatto, E.L. and Formoso, C.T. (1998) *Proceedings IGLS 1998*. Guarujá. Brazil.

Ishikawa, K. (1980) *QC Circle Koryo : General Principles of the QC Circle.* . Tokyo: QC Circle Headquarters, Union of Japanese Scientists and Engineers.

Ishikawa, K. (1985a) *How to Operate QC Circle Activities*. Tokyo: QC Circle Headquarters, Union of Japanese Scientists and Engineers.

Ishikawa, K. (1985b) *What is total quality control?: The Japanese Way*. Englewood Cliffs, NJ: Prentice-Hall.

Ishikawa, K. (1990) *Introduction to Quality Control "Dai-3-pan Hinshitsu Kanri Nyumon"*. 3rd edn. Translated by Loftus, J.H. Lonodn: Chapman & Hall.

Jackson, T.L. (2006) *Hoshin Kanri for the Lean Enterprise*. illustrated edn. Productivity Press.

Japan Human Relations Association (1997a) *Kaizen Teian 1: Developing Systems for Continuous Improvement Through Employee Suggestions*. Portland, Oregon: Productivity Press.

Japan Human Relations Association (1997b) *Kaizen Teian 2: Guiding Continuous Improvement Through Employee Suggestions*. Portland, Oregon: Productivity Press.

Japan Management Association (1985) *Kanban, Just-in-Time at Toyota*. English edn. Translated by Lu, D.J. Stamford, Connecticut; Cambridge, Massachusetts: Productivity Press.

Jha, S., Noori, H. and Michela, J.L. (1996) 'The Dynamics of Continuous Improvement', *International Journal of Quality*, 1(1), pp. 19-47.

Jiang, B., Frazier, G.V. and Heiser, D. (2007) 'China-related POM research: a literature review and suggestions for future research', *International Journal of Operations & Production Management*, 27(7), pp. 662-684.

Jiang, M., Lin, L. and Zhang, H. (2005) '精益生产在中国企业的应用分析, Jingyi shengchan zai Zhongguo qiye de yingyong fenxi', *统计与决策 Statistics and Decision*, (12), pp. 144-146.

Jimmerson, C., Weber, D. and Sobek, I., Durward (2005) 'Reducing Waste and Errors: Piloting Lean Principles at Intermountain Healthcare', *Joint Commission Journal on Quality and Patient Safety*, 31, pp. 249-257.

Johnson, P. and Duberley, J. (2000) *Understanding management research*. London, California & New Delhi: Sage Publications.

Johnson, R.A. and Wichern, D.W. (2007) *Applied multivariate statistical analysis*. Prentice-Hall.

Jomo, K.S., Felker, G. and Rasiah, R. (2001) *Industrial Technology Development in Malaysia: Industry and Firm Studies*. New York: Routledge.

Jones, D.T. (2001) 'the Lean transformation', in Taylor, D. and Brunt, D. (eds.) *Manufacturing Operations and Supply Chain Management, the Lean approach*. Mitcham, Surrey: Thomson Learning, pp. 388 (17-23).

Jones, D.T. (2005) 'Lean: Kaikaku before Kaizen', *Management Services*, 49(4), pp. 6-7.

Jones, D.T. and Womack, J.P. (2002) *Seeing the Whole. Mapping the Extended Value Stream*. Brookline, Massachusetts: The Lean Enterprise Institute.

Jöreskog, K.G. (1974) 'Analyzing psychological data by structural analysis of covariance matrices', in Krantz, D.H., Atkinson, R.C., Luce, R.D. and Suppes, P. (eds.) *Contemporary developments in mathematical psychology*. San Francisco: Freeman, pp. 1-56.

Jöreskog, K.G. (1977) 'Factor Analysis by Least-Squares and Maximum Likelihood Methods', in Enslein, K., Ralston, A. and Wilf, H.S. (eds.) *Statistical Methods for Digital Computers*. New York: John Wiley & Sons, Inc.

Jöreskog, K.G. (1993) 'Testing structural equation models', in Bollen, K.A. and Long, J.S. (eds.) *Testing Structural Equation Models*. Newbusy Park, CA: Safe, pp. 294-316.

Jöreskog, K.G. and Sörbom, D. (2001) *LISREL 8 Structural Equation Modeling with the SIMPLIS Command Language*. Lincolnwood, IL: Scientific Software International, Inc.

Jung, J.Y. and Wang, Y.J. (2006) 'Relationship between total quality management (TQM) and continuous improvement of international project management (CIIPM)', *Technovation*, 26(5–6), pp. 716-722.

Juran, J.M. (1988) *Juran on planning for quality*. New York: Free Press.

JUSE (2010) *QC Circles*. Available at: http://www.juse.or.jp/e/qc/01_qc.html (Accessed: 05/05/2011).

Kaiser, H.F. (1958) 'The varimax criterion for analytic rotation in factor analysis', *Psychometrika*, 23(3), pp. 187-200.

Kaiser, H.F. (1960) 'The application of electronic computers to factor analysis. ', *Educational and Psychological Measurement*, 20, pp. 141-151.

Kaiser, H.F. (1963) 'Image Analysis', in Harris, C.W. (ed.) *Problems in Measuring Change*. Madison, WI: University of Wisconsin Press.

Kaiser, H.F. (1974) 'An index of factorial simplicity ', *Psychometrika*, 39(1), pp. 31-36.

Kaiser, H.F. and Caffrey, J. (1965) 'Alpha factor analysis', *Psychometrika*, 30(1), pp. 1-14.

Kalton, G. (1983) *Introduction to survey sampling*. London: SAGE Publications, Inc.

Kamrani, A.K. and Nasr, E.A. (2008) *Collaborative Engineering: Theory and Practice*. New York: Springer.

Kanji, G.K. (1998) 'Measurement of business excellence', *Total Quality Management*, 9(7), pp. 633-643.

Karlsson, C. (2009) 'Researching Operations Management', in Karlsson, C. (ed.) *Researching Operations Management*. New York and London: Routledge, pp. 6-41.

Karlsson, C. and Ahlstrom, P. (1996) 'Assessing changes towards lean production', *International Journal of Operations & Production Management*, 16(2), pp. 24-41.

Kerrin, M. (1999) 'Continuous improvement capability: assessment within one case study organisation', *International Journal of Operations & Production Management*, 19(11), pp. 1154-1167.

Kerrin, M. and Oliver, N. (2002) 'Collective and individual improvement activities: the role of reward systems', *Personnel Review*, 31(3), pp. 320-337.

Kline, P. (1994) *An easy guide to factor analysis*. London: Routledge.

Kline, R.B. (2005) *Principles and practice of structural equation modeling* Second Edition edn. New York: A Division of Guiford Publications, Inc.

Kobayashi, I. (1990) *20 Keys to Workplace Improvement*. Translated by Smith, W.W. Cambridge, MA: Productivity Press.

Kobayashi, K., Fisher, R. and Gapp, R. (2008) 'Business improvement strategy or useful tool? Analysis of the application of the 5S concept in Japan, the UK and the US', *Total Quality Management & Business Excellence*, 19(3), pp. 245 - 262.

Koh, S.C.L., Demirbag, M., Bayraktar, E., Tatoglu, E. and Zaim, S. (2007) 'The impact of supply chain management practices on performance of SMEs', *Industrial Management & Data Systems*, 107(1), pp. 103-124.

Kondou, S. (2003) 'Striving for Kakushin (continuous innovation) for the 21st century', *International Journal of Technology Management*, 25(6), pp. 517-530.

Kono, T. (1982) 'Japanese management philosophy: Can it be exported?', *Long Range Planning*, 15(3), pp. 90-102.

Koren, Y. (2010) *The Global Manufacturing Revolution: Product-Process-Business Integration and Reconfigurable Systems*. New Jersey: John Wiley and Sons.

Kosandal, P. and Farris, J. (2004) *American Society for Engineering Management - 24th National Conference*. Hilton Alexandria Mark Center, Alexandria, 20-23/10/2003. VA.

Koskela, L. (1992) 'Application of the New Production Philosophy to Construction', *Technical Report*, 72(Center for integrated facility engineering).

Krafcit, J., F (1988) 'Triumph of the lean production system', *Sloan Management Review*, 30(1), pp. 41-52.

Krafcit, J., F (1989) 'A new diet for U.S. Manufacturing', *Technology Review*, 92(1), pp. 28-36.

Krar, S. (2003) 'Continuous improvement ', in Kara, S. and Gill, A. (eds.) *Exploring advanced manufacturing technologies*. New York: Industrial press, p. pp. 448.

Krenzke, T., de Kerckhove, W.V. and Mohadjer, L. (2005) *SA Proceedings of the Joint Statistical*

Meetings.

Krishnaswamy, K.N., Sivakumar, A.I. and Mathirajan, M. (2009) *Management Research Methodology: Integration of Methods and Techniques*. 3rd Edison edn. Delhi: Dorling Kindersley (India) Pvt. Ltd.

Krosnick, J.A. and Fabrigar, L.R. (1997) 'Designing Rating Scales for Effective Measurement in Surveys', in *Survey Measurement and Process Quality*. John Wiley & Sons, Inc., pp. 141-164.

Kupanhy, L. (2007) *JIT/Lean methods and Japanese management*. New York: iUniverse.

Kwaw-Mensah, D. (2008) *Perceptions of agricultural extension educators regarding livestock waste management education in the North Central Region*. Iowa State University [Online]. Available at: http://books.google.co.uk/books?id=L41OrZNyOq8C&printsec=frontcover#v=onepage&q&f=false.

Lambert, D.M. and Harrington, T.C. (1990) 'Measuring nonresponse bias in customer service mail surveys', *Journal of Business Logistics*, 11(2), pp. 5-25.

Landsbergis, P.A. and Cahill, J. (1999) 'The Impact of Lean Production and Related New Systems of Work Organization on Worker Health', *Journal of Qccupational Heal Psychology*, 4(2), pp. 108-130.

Langfield-Smith, K. and Greenwood, M.R. (1998) 'Developing Co-operative Buyer-Supplier Relationships: A Case Study of Toyota', *Journal of Management Studies*, 35(3), pp. 331-353.

Laraia, A.C., Moody, P.E. and Hall, R.W. (1999) *The Kaizen Blitz: Accelerating Breakthroughs in Productivity and Performance*. John Wiley and Sons.

Lawler, E.E.I. and Mohrman, S.A. (1991) 'Quality Circles: After the Honeymoon', *Journal of Management*, 17(1), pp. 25-39.

Lawley, D.N. and Maxwell, A.E. (1962) 'Factor Analysis as a Statistical Method', *Journal of the Royal Statistical Society. Series D (The Statistician)*, 12(3), pp. 209-229.

Lawson, B., Cousins, P.D., Handfield, R.B. and Petersen, K.J. (2009) 'Strategic purchasing, supply management practices and buyer performance improvement: an empirical study of UK manufacturing organisations', *International Journal of Production Research*, 47(10), pp. 2649-2667.

Lee, C. (1996) 'Origin of the Adoption of the Toyota Production System in China', *Japanese Business History Review* 31(2).

Lehmann, D.R. and Hulbert, J. (1972) 'Are Three-Point Scales Awlays Good Enough?', *Journal of Marketing Research*, 9(4), pp. 444-446.

Leseure, M.J. (2002) 'Cladistics as historiography: part I – introduction to cladistics', *Management Decision*, 40(6), pp. 603-613.

Levinson, W.A. (2002) *Henry Ford's Lean Vision, Enduring Principles from the First Ford Motor Plant*. New York, NY: Productivity Press.

Levinson, W.A. and Tumbelty, F. (1997) *SPC Essentials and Productivity Improvement: A Manufacturing Approach*. Milwaukee, WI: American Society for Qualit, Quality Press.

Lewis, D.L. (1987) *The Public Image of Henry Ford: An American Folk Hero and His Company*. Detroit: Wayne State University Press.

Lewis, M.A. (2000) 'Lean production and sustainable competitive advantage', *International Journal of Operations & Production Management*, 20(8), p. 959.

Li, J. (2004) *Jie gou fang cheng mo xing dao lun 结构方程模型导论*. Anhui: Daxue Chubanse.

Li, J. (2010) *General information about Guangdong automotive industry (Qi Che Gong Ye)*. Government report: the People's Government of Guangdong. [Online]. Available at: http://www.gd.gov.cn/govinc/nj2010/05jj/050609.htm.

Li, S., Ragu-Nathan, B., Ragu-Nathan, T.S. and Rao, S.S. (2006) 'The impact of supplychain management practices on competitive advantage and organizational performance', *The International Journal of Management Science*, 34, pp. 104-124.

Liff, S. and Posey, P.A. (2004) *Seeing is Believing - How the New Art of Visual Management Can Boost Performance Throughout Your Organisation*. New York: AMACOM.

Liker, J.K. (2004) *The Toyota Way, 14 Management Principles from the world's greatest manufacturer*. London: Mc-Graw-Hill.

Liker, J.K. and Hoseus, M. (2008) *Toyota Culture: The Heart and Soul of the Toyota Way*. London: McGraw-Hill.

Liker, J.K. and Meier, D. (2006) *the Toyota Way Fieldbook: a practical guide for implementing Toyota's 4Ps*. McGraw-Hill.

Likert, R. (1932) 'A technique for the measurement of attitudes', *Archives of Psychology*, 22 140, p. 55.

Lillrank, P. (1995) 'The Transfer of Management Innovations from Japan', *Organization Studies*, 16(6), pp. 971-989.

Lillrank, P. and Kano, N. (1989) *Continuous improvement: quality control circles in Japanese industry*. Michigan: The University of Michigan.

Lillrank, P., Shani, A.B. and Lindberg, P. (2001) 'Continuous improvement: Exploring alternative organizational designs', *Total Quality Management*, 12(1), pp. 41-55.

Lim, K.K., Ahmed, P.K. and Zairi, M. (1999) 'Managing waste and looking beyond: the IMI approach', *The TQM Magazine*, 11(5), pp. 304-310.

Lin, C., Chow, W.S., Madu, C.N., Kuei, C.-H. and Pei Yu, P. (2005) 'A structural equation model of supply chain quality management and organizational performance', *International Journal of Production Economics*, 96(3), pp. 355-365.

Lindner, J.R., Murphy, T.H. and Briers, G.E. (2001) 'Handling nonresponse in social science research', *Journal of Agricultural Education*, 42(4), pp. 43-53.

Loehlin, J.C. (2004) *Latent variable models, an introduction to factor, path, and structural equation analysis* 4th Edition edn. London: Lawrence Erlbaum Associates, Publishers.

Lohr, S.L. (2009) *Sampling: Design And Analysis*. 2nd Edition edn. Boston, : Brooks/Cole, Cengage Learning.

López, R.R. and Morales, S.N. (2011) *International Conference on Industrial Engineering Theory, Applications and Practice*. Stuttgart, Germany, 20-23 September 2011.

Lowenberg, J.S. (1993) 'Interpretive research methodology: Broadening the dialogue', *Advances in Nursing Science*, 16(2), pp. 57-69.

Lu, C.-H. (2006) 'Assessing Construct Validity: The Utility of Factor analysis', *Journal of Educational Measurement and Statistics*, 15, pp. 79-94.

Lunneborg, C.E. (1987) 'Bootstrap applications for the behavioral sciences', *Educational and Psychological Measurement*, 47(3), pp. 627-929.

Ma, J. (2008) Pilot study, Nissan site visit, 05/03/2008.

Ma, J., Hicks, C. and McGovern, T. (2013) *22nd International Conference on Production Research*. Foz do Iguaçu, Inguassu Falls, , 28/07/2013. Brazil.

Ma, J., McGovern, T. and Hicks, C. (2010) *Sixteenth International Working Seminar on Production Economics*. Congress Innsbruck, 03/2010. Austria.

MacCallum, R.C., Roznowski, M. and Necowitz, L.B. (1992) 'Model modifications in covariance structure analysis: The problem of capitalization on chance', *Psychological Bulletin*, 111(3), pp. 490-504.

Main, B., Taubitz, M. and Wood, W. (2008) 'You Cannot Get Lean Without Safety', *Professional Safety*, 53(1), pp. 38-42.

Malaise, O.v. (1995) 'Shop floor management: integrated control', *Manufacturing Engineering*, 1995, pp. 284-286.

Malhotra, M.K. and Grover, V. (1998) 'An assessment of survey research in POM: from constructs to theory', *Journal of Operations Management*, 16(4), pp. 407-425.

Maranto-Vargas, D. and Gómez-Tagle Rangel, R. (2007) 'Development of internal resources and capabilities as sources of differentiation of SME under increased global competition: A field study in Mexico', *Technological Forecasting and Social Change*, 74(1), pp. 90-99.

Marczyk, G., DeMatteo, D. and Festinger, D. (2005) *Essentials of research design and methodology*. New Jersey, & Canada: John Wiley & Sons, Inc.

Marin-Garcia, J.A., del Val, M.P. and Martin, T.B. (2008) 'Longitudinal study of the results of continuous improvement in an industrial company', *Team Performance Management*, 14(1/2), pp. 1352-7592.

Marsh, P., Bryant, C. and Milne, R. (2013) 'China to outstrip Europe car production', *Financial Times*edn), 01/01/2013. [Online] Available at: http://www.ft.com/cms/s/0/591fb1c8-5119-11e2-b287-00144feab49a.html#axzz2IQAwnJUV.

Masaki, H. (2006) *toyota houshiki de shigoto mo jibun mo kaerareru daredemo kaizen dekiru shigoto no sukiru (One can Change Work and Ourselves by the Toyota Method)*. Translated by 正木英昭. Tokyo: 株式會社廣濟堂.

Masters, K. and Moss, R. (1983) *The Change Masters: Innovation for Productivity in the American Corporation*. University o f Michigan: Simon and Schuster.

McCutcheon, D.M. and Meredith, J.R. (1993) 'Conducting case study research in operations management', *Journal of Operations Management*, 11(3), pp. 239-256.

McDonald, R.P. and Ho, M.-H.R. (2002) 'Principles and practice in reporting structural equation analyses', *Psychological Methods*, 7(1), pp. 64-82.

McNabb, D.E. (2008) *Research methods for public administration and nonprofit management: quantitative and quanlitative approaches*. New York: M.E. Sharpe, Inc.

McNeill, P. and Chapman, S. (2005) *Research Methods*. Third Edition edn. New York: Routledge.

McNichols, T., Hassinger, R. and Bapst, G.W. (1999) 'Quick and continuous improvement through kaizen blitz', *Hospital Materiel Management Quarterly*, 20(4), pp. 1-7.

McQuitty, S. (2004) 'Statistical power and structural equation models in business research', *Journal of Business Research*, 57(2), pp. 175-183.

Medsker, G.J., Williams, L.J. and Holahan, P.J. (1994) 'A review of current practices for evaluating causal models in organizational behavior and human resources management research', *Journal of Management*, 20(2), pp. 439-464.

Mendez-Vilas, A. (2012) *Microbes in Applied Research: Current Advances and Challenges*. World Scientific Publishing Company, Incorporated.

Meredith, J. (1998) 'Building operations management theory through case and field research', *Journal of Operations Management*, 16(4), pp. 441-454.

Meredith, J.R., Raturi, A., Amoako-Gyampah, K. and Kaplan, B. (1989) 'Alternative research paradigms in operations', *Journal of Operations Management*, 8(4), pp. 297-326.

Mestre, M., Stainer, A., Stainer, L. and Strom, S. (2000) 'Visual Communications - the Japanese Experience', *Corporate Communications: An International Journal*, 5(1), pp. 34-41.

Metropolis, N. and Ulam, S. (1949) 'The Monte Carlo Method', *Journal of the Amarican Statistical Association*, 44(247), pp. 335-341.

Meyer, A.D. and Ferdows, K. (1990) 'Influence of manufacturing improvement programmes on performance', *International Jounral of Operations & Production Management*, 10(2), pp. 120-131.

Miina, A. (2012) ' Lean Problem: Why Conpanies Fail with Lean Implementation?', *Management*, 2(5), pp. 232-250.

Milakovich, M.E. (2006) *Improving Service Quality in the Global Economy Achieving High Performance in public and Private Sectors* Second Edition edn. Boca Raton: Auerbach Publications, Taylor & Francis Group.

Miller, D.C. and Salkind, N.J. (2002) *Handbook of Research Design and social Measurement*. 6th edition edn. London: Sage Publications Ltd.

Miltenburg, J. (2005) *Manufacturing strategy: how to formulate and implement a winning plan*. New York, NY: Productivity Press.

Minor, I.I.I.E.D., Hensley, R.L. and Wood, J.D.R. (1994) 'A Review of Empirical Manufacturing Strategy Studies', *International Journal of Operations & Production Management*, 14(1), pp. 5-25.

Miom, M.E. and Caropenter, K. (2000) '5S for everyone', *Operations Management*, October, pp. 17-19.

Miozzo, M. and Walsh, V. (2006) *International competitiveness and technological change*. Oxford: Oxford University Press.

Mitchel, J.C. (1982) 'Case and Situation analysis', in Don Handelman, T.M.S.E. (ed.) *The Manchester School, Practice and Ethnographic Praxis in Anthropology*. Berghahn Books, pp. p23-42.

Mitchell, M.L. and Jolley, J.M. (2010) *Research Design Explained*. 7 Edition edn. Belmont: Wadsworth, Cengage Learning.

Mitchell, R.J. (1992) 'Testing Evolutionary and Ecological Hypotheses Using Path Analysis and Structural Equation Modelling', *Functional Ecology*, 6(2), pp. 123-129.

Monden, Y. (1983) *Toyota Production System, Practical Approach to Production Management*. Norcross, Georgia: Industrial Engineering and Management Press.

Monden, Y. (1994) *Toyota Production System : an integrated approach to just-in-time*. 2nd edn. London: Chapman & Hall.

Mooney, C.Z. and Duval, R.D. (1993) *Bootstrapping: A Nonparametric Approach to Statistical Inference*. Newbury Park, CA: Sage Publications.

Morgan, J.M. and Liker, J.K. (2006) *The Toyota Product Development System: Integrating People, Process, and Technology*. New York: Productivity Press.

Morris, J., Lowe, J. and Willkinson, B. (1998) ''Front-end reflections': supervisory systems in the UK's Japanese transplants and in 'Japanized' companies', *employee Relations*, 20(3), pp. 261-270.

Morrision, J. (1958) 'The lognormal distrubution in quality control', *Journal of the royal statistical society*, 7(3 (Nov. 1958)), pp. 160-172.

Moxham, C. and Greatbanks, R. (2001) 'Prerequisites for the implementation of the SMED methodology: A study in a textile processing environment', *International Journal of Quality & Reliability Management*, 18(4), pp. 404-414.

Mplus Development Team (2013) *About Mplus* Available at: http://www.statmodel.com/company.shtml (Accessed: 01/01/2013).

Muchinsky, P.M. (2000) *Psychology Applied to Work*. 6th Edition edn. Belmont, CA: Thompson Wadsworth.

Murata, K. (2007) *New Point of Common Thinking for Innovation - a case study of Yongamen at Hokuriku Japan*. Japan Advanced Institute of Science and Technology.

Murman, E., Allen, T., Bozdogan, K., Cutcher-Gershenfeld, J., McManus, H., Nightingale, D., Rebentisch, E., Shields, T., Stahl, F., Walton, M., Warmkessel, J., Weiss, S. and Widnall, S. (2002) *Lean Enterprise Value, Insights from MIT's Lean Aerospace Initiative*. New York, NY: Palgrave.

Muthen, B. (1973) 'Contributions to factor analysis of dichotomous variables ', *Psychometrika*, 43(4), pp. 551-560.

Muthiah, K.M.N. and Huang, S.H. (2007) 'Overall throughput effectiveness (OTE) metric for factory-level performance monitoring and bottleneck detection', *International Journal of Production Research*, 45(20), pp. 4753-4769.

Nagati, H. and Rebolledo, C. (2012) 'The role of relative absorptive capacity in improving suppliers' operational performance', *International Journal of Operations & Production Management*, 32(5), pp. 611-630.

Nakajima, S. (1989) *TPM development program: implementing totol productive maintenance*. Cambridge, MA: Productivity Press.

National Bureau of Statistics of China (2008) 'Annual Year Book'. 12/08/2008. National Bureau of Statictics of China. Available at: http://www.stats.gov.cn/english/.

Neagoe, L. and Marascu_Klein, V. (2009) *International Conference on Economic Engineering and Manufacturing Systems*. .

Nelson, D., Moody, P.E. and Mayo, R. (1998) *Powered by Honda: developing excellence in the global enterprise*. Danvers: Wiley.

Nersesian, R.L. (2000) *Trends and tools for operations management: an updated guide for executives and managers*. Westport: Greenwood Publishing Group.

Nevitt, J. and Hancock, G.R. (2001) 'Performance of Bootstrapping Approaches to Model Test Statistics and Parameter Standard Error Estimation in Structural Equation Modeling', *Structural Equation Modeling: A Multidisciplinary Journal*, 8(3), pp. 353-377.

Neyman, J. and Pearson, E.S. (1933) 'On the Problem of the Most Efficient Tests of Statistical Hypotheses', *Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character*, 231(ArticleType: research-article / Full publication date: 1933 / Copyright © 1933 The Royal Society), pp. 289-337.

Ni, W. and Sun, H. (2009) 'The relationship among organisational learning, continuous improvement and performance improvement: An evolutionary perspective', *Total Quality Management & Business Excellence*, 20(10), pp. 1041-1054.

Nihon HR Kyōkai (1995) *The Improvement Engine: Creativity & Innovation Through Employee Involvement : The Kaizen Teian System*. 1st edn. Tokyo: Productivity Press.

Nilsson-Witell, L., Antoni, M. and Dahlgaard, J.J. (2005) 'Continuous improvement in product development: Improvement programs and quality principles', *International Journal of Quality & Reliability Management*, 22(8), pp. 753-768.

NKS, N.K.S., Ltd. and Factory Magazine (1987) *Poka-Yoke Improving Product Quality by Preventing Defects*. English edn. Portland, Oregon: Productivity Press.

Norcliffe, M. (2006) *The Automotive Industry in Emerging Markets: CHINA*. Blue Ibex Ltd. Available at: http://NCL.eblib.com/patron/FullRecord.aspx?p=267556 (Accessed: 05/05/2009).

Norwood, E.P. (1931) *Ford: Men and Methods*. Garden City, NY: Doubleday, Doran & Company Inc. .

Nunnally, J.C. and Bernstein, I.H. (1994) *Psychometric theory*. Third Edition edn. London: McGraw-Hill.

O'hEocha, M. (2000) ' A study of the influence of company culture, communications and employee attitudes on the use of 5Ss for environmental management at Cooke Brothers Ltd', *The TQM Magazine*, 12(5), pp. 321-330.

Oakland, J.S. (2001) *Total Organizational Excellence: Achieving World-class Performance*. Butterworth-Heinemann.

Ohno, T. (1979) *Feng Tian Sheng Chan Fang Shi/丰田生产方式*. Translated by Li, C. 李., Zhao, S.赵. and Lu, Y.吕. Beijin: Beijing Chu Ban She/北京出版社.

Ohno, T. (1988a) *Toyota production system: beyond large-scale production*. Productivity Press.

Ohno, T. (1988b) *Workplace Management*. Productivity Press.

OICA (2012) 'Production Statistics by Countries'. 12/08/2008. OICA. Available at: http://oica.net/.

Oke, A. and Kach, A. (2012) 'Linking sourcing and collaborative strategies to financial performance: The role of operational innovation', *Journal of Purchasing and Supply Management*, 18(1), pp. 46-59.

Oke, A.E., Ogunsami, D.R. and Ogunlana, S. (2012) 'Establishing a common ground for the use of structural equation modelling for construction related research studies', *Australasian Journal of Construction Economics and Building*, 12(3), pp. 89-94.

Okino, K. (1995) 'Toyota changes its famous production system', *Automotive industries*, 175(2), p. 44.

Oliver, N., Delbridge, R. and Barton, H. (2002) *Lean Production and Manufacturing Performance Improvement in Japan, the U.K. and U.S. 1994-2001*. This Working Paper forms part of the CBR Research Programme on Industrial Organisation, Competitive Strategy and Business Performance.

Oliver, N., Delbridge, R. and Lowe, J. (1996a) 'The European auto components industry', *International Journal of Operations & Production Management*, 16(11), pp. 85-97.

Oliver, N., Delbridge, R. and Lowe, J. (1996b) 'Lean Production Practices: International Comparisons in the Auto Components Industry', *British Journal of Management*, 7(special issue), pp. 29-44.

Oliver, N., Delbridge, R. and Lowe, J. (1998) 'Japanization on the shopfloor', *Employee Relations*, 20(3), pp. 248-260.

Olsson, U.H., Foss, T., Troye, S.V. and Howell, R.D. (2000) 'The Performance of ML, GLS, and WLS Estimation in Structural Equation Modeling Under Conditions of Misspecification and Nonnormality', *Structural Equation Modeling: A Multidisciplinary Journal*, 7(4), pp. 557-595.

Onglatco, M.L.U. (1985) 'A preliminary assessment of quality circle involvement - some research findings based on Japanese and Filipino samples ', *Proceedings of the Asian regional*, pp. 93-121.

Oppenheim, A.N. (1992) *Questionnaire design and attitude measurement* New Edition edn. London and New York: Continuum.

Ortiz, C.A. and Park, M.R. (2011) *Visual Controls: Applying Visual Management to the Factory*. New York, NY: Productivity Press, Taylor & Francis Group.

Osada, T. (1991) *The 5S's Five Keys to a Total Quality Environment*. Minato-ku, Tokyo: Asian Productivity Organization.

Osono, E., Shimizu, N. and Takeuchi, H. (2008) *Extreme Toyota: Radical Contradictions That Drive Success at the World's Best Manufacturer*. Hoboken, New Jersey and Canada: John Wiley and Sons, Inc.

Pallant, J. (2007) *SPSS survival manual*. Berkshire, England: Open University Press.

Parry, G.C. and Turner, C.E. (2006) 'Application of lean visual process management tools', *Production Planning & Control*, 17(1), pp. 77-86.

Patty, R. and Denton, M.A. (2010) *The end of project overruns, Lean and byeond for engineering, procurement and construction* Boca Ratom, Florida: Univeral Publishers.

Pavnaskar, S.J., Gershenson, J.K. and Jambekar, A.B. (2003) 'Classification scheme for lean manufacturing tools', *International Journal of Production Research*, 41(13), pp. 3075-3090.

Pearl, D.K. and Fairley, D. (1985) 'Testing for the Potential for Nonresponse Bias in Sample Surveys', *Public Opinion Quarterly*, 49(4), pp. 553-560.

Pearson, E.S. (1936) 'Karl Pearson: An appreciation of some aspects of this life and work', *Biometrika*, 28(3/4), pp. 193-257.

Pearson, K. (1901) 'On lines and planes of closest fit to systems of points in space', *Philosophical Magazine*, 2(6), pp. 559-572.

Pedhazur, E.J. and Schmelkin, L.P. (1991) *Measurement, design, and analysis: an integrated approach*. London: Lawrence Erlbaum Associates, Publishers.

Peng, D.X., Schroeder, R.G. and Shah, R. (2011) 'Competitive priorities, plant improvement and innovation capabilities, and operational performance: A test of two forms of fit', *International Journal of Operations & Production Management*, 31(5), pp. 484-510.

Pescod, W.D.T. (1994) 'Effective Use of a Common Problem-solving Process as an Integral Part of TQM', *International Journal of Health Care Quality Assurance*, 7(7), pp. 10-13.

Peter, D.W. (1990) *Production management: Japanese and British approaches*.

Peters, T. (1989) *Thriving on Chaos, Handbook for a Management Revolution*. first published in the USA 1987 by Alfred A. Knopf, Inc.

first published in Great Britain 1988 by Macmollan London Limited edn. London: Pan Books Ltd.

Pett, M.A., Lackey, N.R. and Sullivan, J.J. (2003) *Making sense of factor analysis: the use of factor analysis for instrument development in health care research*. Thousand Oaks, California: Sage Publications, Inc.

Pil, F.K. and Fujimoto, T. (2007) 'Lean and reflective production: the dynamic nature of production models', *International Journal of Production Research* 45(16), pp. 3741-3761.

Poe, R. (1991) 'The new discipline: unleash group intelligence in your company', *Success*, July-august.

Polcyn, K.A. and Engelman, S.S. (2006) *NAPEO Conference*. Boca Raton, 11/09/2006-13/09/2006. FL.

Politis, J.D. (2005) 'QFD, organisational creativity and productivity', *International Journal of Quality & Reliability Management*, 22(1), pp. 59-71.

Polito, T. and Watson, K. (2006) 'Just-in-Time Under Fire: The Five Major Constraints Upon JIT Practices', *Journal of American Academy of Business, Cambridge*, 9(1), pp. 8-13.

Poropat, A. and Kellett, J. (2009) 'Buddhism and TQM: An alternative explanation of Japan's adoption of Total Quality Management', [Online]. Available at: http://www98.griffith.edu.au/dspace/stats?itemId=11965 (Accessed: 2010).

Prado, J.C. (1997) 'Increasing competitiveness with continuous improvement', *Industrial Management*, 39(4), p. 25.

Prado, J.C. (2001) 'Beyond quality circles and improvement teams', *Total Quality Management*, 12(6), pp. 789-798.

Prajogo, D.I. (2000) 'Indise Continuous Improvement - a literature review', *Jurusan Teknik Industri*, 2(2), pp. 65-71.

Prajogo, D.I. (2002) *The relationship between total quality management practices and innovation performance*. Monash University.

Prajogo, D.I. and Sohal, A.S. (2001) 'TQM and innovation: a literature review and research framework', *Technovation*, 21(9), pp. 539-558.

Prajogo, D.I. and Sohal, A.S. (2006) 'The integration of TQM and technology/R&D management in determining quality and innovation performance', *OMEGA*, 34(3), pp. 296-312.

Prasad, S. and Babbar, S. (2000) 'International operations management research', *Journal of Operations Management*, 18(2), pp. 209-247.

Productivity Development Team (2003) *Identifying Waste on the Shopfloor (Shopfloor Series)*. New York: Productivity Press.

Quinlan, C. (2011) *Business Research Methods*. Australia, Brazil, Japan, Korea, Mexico, Singapore, Spain, UK and US: South-Western Cengaga Learning.

Radeka, K. (2007) 'The Toyota Product Development System: Integrating People, Process and Technology by James M. Morgan and Jeffrey K. Liker', *Journal of Product Innovation Management*, 24(3), pp. 276-278.

Radharamanan, R., Godoy, L.P. and Watanabe, K.I. (1996) 'Quality and productivity improvement in a custom-made furniture industry using Kaizen', *Computers & Industrial Engineering*, 31(1-2), pp. 471-474.

Radnor, Z.J., Holweg, M. and Waring, J. (2012) 'Lean in healthcare: The unfilled promise?', *Social Science & Medicine*, 74(3), pp. 364-371.

Rahman, S.-U. (2001) 'Total quality management practices and business outcome: Evidence from small and medium enterprises in Western Australia', *Total Quality Management*, 12(2), pp. 201-210.

Rao, C.R. (1955) 'Estimation and tests of significance in factor analysis', *Psychometrika*, 20(2), pp. 93-111.

Rao, P. (2004) 'Greening production: a South-East Asian experience', *Green production*, 24(3), pp. 289-320.

Rao, P. and Holt, D. (2005) 'Do green supply chains lead to competitiveness and economic performance?', *International Journal of Operations & Production Management*, 25(9), pp. 898-916.

Rapp, C. and Eklund, J. (2002) 'Sustainable development of improvement activities—the long-term operation of a suggestion scheme in a Swedish company', *Total Quality Management*, 13(7), pp. 945-969.

Rapp, C. and Eklund, J. (2007) 'Sustainable development of a suggestion system: Factors influencing improvement activities in a confectionary company', *Human Factors and Ergonomics in Manufacturing & Service Industries*, 17(1), pp. 79-94.

Rausch, M.L. (2007) *Henry Ford and the Model T Car*. Milwaukee: Gareth Stevens.

Recht, R. and Wilderom, C. (1998) 'Kaizen and culture: on the transferability of Japanese suggestion systems', *International Business Review*, 7(1), pp. 7-22.

Rigdon, E.E. (1994) 'Calculating degrees of freedom for a structural equation model', *Structural Equation Modeling*, 1(3), pp. 274-278.

Rinehart, J., Huxley, C. and Robertson, D. (1997) *Just Another Car Factory?: Lean Production and Its Discontents* ILR Press.

Rita, H.-A. (2001) 'Standard operating procedures - a novel perspective', *The Quality Assurance Journal*, 5(4), pp. 207-219.

Robinson, A. (2001) 'Origins of the modern Japanese management style: Kaizen and elimination of waste', in Robinson, A. (ed.) *Continuous improvement in operations: a systematic approach to waste reduction*. Cambridge: MA: Productivity Press.

Robinson, A.G. and Schroeder, D.M. (2009) 'The Role of Front-line ideas in Lean Performance Improvement', *Quality Management Journal* 16(4), pp. 27-40.

Román, L.F. (2009) *A case of acquisition, transmission and use of information to control a manufacturing process*. Universitat Politècnica de Catalunya.

Rong, T. (2009) *AMOS yu yanjiu fangfa*. Chongqing: Chongqin Daxue Chubanshe.

Rooney, S.A. and Rooney, J.J. (2005) 'Lean Glossary', *Quality progress*, 38(6), pp. 41-47.

Rother, M. and Shook, J. (2003) *Learning to See: Value-stream mapping to create value and eliminate muda*. version 1.3 edn. Cambridge, Massachusetts: The Lean Enterprise Institute.

Rungtusanatham, M.J., Choi, T.Y., Hollingworth, D.G., Wu, Z. and Forza, C. (2003) 'Survey research in operations management: historical analyses', *Journal of Operations Management*, 21(4), pp. 475-488.

Saha, A. (1994) 'Culture and the development of technology in Japan', *Technology in Society*, 16(2), pp. 225-241.

Sako, M. (2004) 'Supplier development at Honda, Nissan and Toyota: comparative case studies of organizational capability enhancement', *Industrial and Corporate Change*, 13(2), pp. 281-308.

Salvendy, G. (2001) *Handbook of Industrial Engineering, technology and Operations Management*. third edition edn. America: Wiley-Interscience Publication.

Santos, A. and Powell, J.A. (2001) 'Assessing the level of teamwork in Brazilian and English construction sites', *Leadership & Organization Development Journal*, 22(4), pp. 166-174.

Saris, W.E. and Satorra, A. (1993) 'Power evaluations in structural equation models', in Bollen, K.A. and Long, J.S. (eds.) *Testing structural equation models*. Newbusy Park, CA: SAGE, pp. 181-204.

Saunders, M., Lewis, P. and Thornhill, A. (2007) *Research Methods for Business Students*. Fourth Edition edn. Esses: Pearson Education Limited.

Savolainen, T.I. (1999) 'Cycles of continuous improvement', *International Journal of Operations & Production Management*, 19(11), pp. 1203-1222.

Sayer, N.J. and Williams, B. (2012) *Lean For Dummies*. 2nd edition edn. Hoboken, NJ: John Wiley & Sons, Inc.

Scaffede, R. (2002) 'What It Takes to Turn Manufacturing Lean: The Experience of Donnelly Corporation', *Journal of Organizational Excellence*, 21(4), pp. 3-16.

Scarbrough, H. and Terry, M. (1998) 'Forget Japan: the very British response to lean production', *Employee Relations*, 20(3), pp. 224-236.

Schonberger, R.J. (1982a) *Japanese Manufacturing Techniques, Nine Hidden Lessons in Simplicity* New York: The Free Press.

Schonberger, R.J. (1982b) 'Some observations on the advantages and implementation issues of just-in-time production systems', *Journal of Operations Management*, 3(1), pp. 1-11.

Schonberger, R.J. (1986) *World Class Manufacturing: The Lessons of Simplicity Applied*. University of Michigan: Free Press.

Schonberger, R.J. (2006) 'Japanese production management: An evolution--With mixed success', *Journal of Operations Management*, 25(2), pp. 403-419.

Schonberger, R.J. and Gilbert, J.P. (1983) 'Just-In-Time Purchasing: A Challenge for U.S. Industry', *California Management Review*, 26(1), p. 54.

Schroeder, D.M. and Robinson, A.G. (1991) 'America's Most Successful Export to Japan: Continuous Improvement Programs', *Sloan Management Review*, 32(3), pp. 67-81.

Schumacker, R.E. and Lomax, R.G. (2004) *A beginner's guide to structural equation modeling*. Second Edition edn. London: Lawrence Erlbaum Associates, Publishers.

Schuring, R.W. and Luijten, H. (2001) 'Reinventing suggestion sysytems for continuous improvement', *International Journal of Technology Management*, 22(4), pp. 359-372.

Schwab, A.J. (2013) *Detecting outliers*. Available at: http://www.utexas.edu/courses/schwab/ (Accessed: 05/05/2013).

Schwerin, J. (2004) 'The evolution of the Clyde region's shipbuilding innovation system in the second half of the nineteenth century', *Journal of Economic Geography*, 4(1), pp. 83-101.

Scudder, G.D. and Hill, C.A. (1998) 'A review and classification of empirical research in operations management', *Journal of Operations Management*, 16(1), pp. 91-101.

Sekimura, T. and Maruyama, T. (2006) 'Development of Enterprise Business Application Software by Introducing Toyota Production System', *Fujitsu Scientific and Technical Journal*, 42(3), pp. 407-443.

Seth, D. and Gupta, V. (2005) 'Application of value stream mapping for lean operations and cycle time reduction: an Indian case study', *Production Planning & Control*, 16(1), pp. 44-59.

Seyedhosseini, S.M., Taleghani, A.E., Bakhsha, A. and Partovi, S. (2011) 'Extracting leanness criteria by employing the concept of Balanced Scorecard', *Expert Systems with Applications*, 38(8), pp. 10454-10461.

Shah, R. and Goldstein, S.M. (2006) 'Use of structural equation modeling in operations management research: Looking back and forward', *Journal of Operations Management*, 24(2), pp. 148-169.

Shah, R. and Ward, P.T. (2003) 'Lean manufacturing: context, practice bundles, and performance', *Journal of Operations Management*, 21(2), pp. 129-149.

Shah, R. and Ward, P.T. (2007) 'Defining and developing measures of lean production', *Journal of Operations Management*, 25(4), pp. 785-805.

Shamah, R.A.M. (2013a) 'Measuring and building lean thinking for value creation in supply chains', *International Journal of Lean Six Sigma*, 4(1), pp. 17-35.

Shamah, R.A.M. (2013b) 'A Model for Applying Lean Thinking to Value Creation', *International Journal of Lean Six Sigma*, 4(2).

Shamshurin, A. (2011) *Beyond Lean Manufacturing: the Productivity, Innovator's and Proactivity Dilemmas resolved*. RMIT University.

Shazali, N.A., Habidin, N.F., Ali, N., Khaidir, N.A. and Jamaludin, N.H. (2013) 'Lean Healthcare Practice and Healthcare Performance in Malaysian Healthcare Industry', *International Journal of Scientific and Research Publications*, 3(1), pp. 1-5.

Sheikh, K. and Mattingly, S. (1981) 'Investigating non-response bias in mail surveys', *Journal of Epidemiology and Community Health*, 35(4), pp. 293-296.

Sheridan, J.H. (1997) 'Kaizen Blitz', *Industry week*, 246(16), pp. 18-27.

Shewhart, W.A. (1931) *Economic control of quality of manufactured product* London: Macmillan.

Shewhart, W.A. (1986) 'Statistical Method from the Viewpoint of Quality Control Forward by ', in Deming, W.E. (ed.) New York: Dover Publications, Inc., p. pp. 155.

Shingo, S. (1986) *Zero Quality control: Source Inspection and the Poka-yoke System*. Translated by Dillon, A.P. Cambridge, MA: Productivity.

Shingo, S. (1987) *The Sayings of Shigeo Shingo: Key Strategies for Plant Improvement*. Translated by Dillon, A.P. Cambridge, MA: Productivity Press.

Shingo, S. (1989) *A study of the Toyota production system from an industrial engineering viewpoint* Rev. edn. Translated by Dillon, A.P. Cambridge, Mass.: Productivity Press.

Shingo, S. (1990) *Modern Approaches to Manufacturing Improvement: The Shingo System* Translated by Robinson, A. Cambridge, Massachusetts: Productivity Press.

Shingo, S. (1992) *The Shingo Production Management System: Improving Process Functions* Productivity Press.

Shingo, S. and Bodek, N. (1988) *Non-Stock Production: The Shingo System for Continuous Improvement*. Productivity Press.

Shingo, S. and Dillon, A.P. (1985) *A Revolution in Manufacturing: The SMED System*. by Productivity press.

Shinkle, G. (2005) 'In Search of Lean Management', *Manufacturing Engineer*, 84(2), pp. 44-47.

Shook, C.L., Ketchen, D.J., Hult, G.T.M. and Kacmar, K.M. (2004) 'An assessment of the use of structural equation modeling in strategic management research', *Strategic Management Journal*, 25(4), pp. 397-404.

Sillince, J.A.A., Sykes, G.M.H. and Singh, D.P. (1996) 'Implementation, problems, success and longevity of quality circle programmes: A study of 95 UK organizations', *International Jounral of Operations & Production Management*, 16(4), pp. 88-111.

Simons, D. and Zokaei, K. (2005) 'Application of lean paradigm in red meat processing', *British Food Journal*, 107(4), pp. 192-211.

Singh, R.K. and Davis, M.E. (2007) 'Measurement of continuous improvement activities in a production environment ', *The International Journal of Applied Management and Technology*, 5(1), pp. 99-120.

Skinner, W. (1969) 'Manufacturing - missing link in corporate strategy', *Harvard Business Review*, (49), pp. 136-145.

Slack, N., Chambers, S. and Johnston, R. (2001) *Operations management*. Third+ Edition edn. Essex: Pearson Education Limited.

Slack, N., Chambers, S. and Johnston, R. (2007) *Operations Management* Fifth edition edn. England: Pearson Education Limited.

Smith, L.I. (2002) 'A tutorial on Principal Components analysis', *University of Otago* [Online]. Available at: http://www.cs.otago.ac.nz/cosc453/student_tutorials/principal_components.pdf (Accessed: 11/11/2013).

So, S. and Sun, H. (2011) 'An extension of IDT in examining the relationship between electronic-enabled supply chain integration and the adoption of lean production', *International Journal of Production Research*, 49(2), pp. 447-466.

Sohal, A.S. and Egglestone, A. (1994) 'Lean Production: Experience among Australian Organizations', *International Journal of Operations & Production Management*, 14(11), pp. 35-51.

Soltero, C. and Waldrip, G. (2002) 'Using Kaizen to Reduce Waste and Prevent Pollution', *Environmental Quality Management*, 11(3), pp. 23-38.

Sorensen, C.E., Lewis, D.L. and Williamson, S.T. (2006) *My Forty Years with Ford*. Wayne State University Press.

Soriano-Meier, H. (2002) 'A model for evaluating the degree of leanness of manufacturing firms', *Integrated Manufacturing Systems*, 13(2), pp. 104-109.

Spearman, C. (1904a) '"General Intelligence," Objectively Determined and Measured', *The American Journal of Psychology*, 15(2), pp. 201-292.

Spearman, C. (1904b) 'The proof and measurement of association between two things', *American Journal of Psychology*, 15(1), pp. 72-101.

Spearman, C. (1927) *The abilities of man*. New York: The Macmillan company.

SSI (2012) *Scientific Software International*. Available at: http://www.ssicentral.com/lisrel/index.html#overview (Accessed: 01/01/2013).

St. Pierre, M., Hofinger, G., Buerschaper, C. and Simon, R. (2011) *Crisis Management in Acute Care Settings: Human Factors, Team Psychology, and Patient Safety in High Stakes Environment*. 2nd edition edn. Heidelberg: Springer.

Stangor, C. (2011) *Research Methods for the Behavioral Sciences*. 4th Edition edn. Belmont, CA: Wadsworth, Cengage Learning.

Steenhuis, H.-J. and Bruijn, E.J. (2006) *POMS: Production and Operations Management Society*. Available at: http://doc.utwente.nl/73618/.

Stevens, J. (2002) *Applied multivariate statistics for the social sciences*. Fourth Edition edn. Routledge.

Stewart, T.A. and Raman, A.P. 85 (2007) 'Lessons from Toyota's long drive. (Cover Story)' [Interview]. Harvard Business School Publication Corp., pp. 74-83. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=25354249&site=ehost-live.

Stigum, B.P. (1990) *Toward a Formal Science of Economics: The Axiomatic Method in Economics and Econometrics*. Massachusetts: Massachusetts Institute of Technology.

Streiner, D.L. (2006) 'Building a better model: an introduction to structural equation modelling', *Canadian Journal of Psychiatry*, 51(5), pp. 317-324.

Sugimori, Y., Kusunoki, K., Cho, F. and Uchikawa, S. (1977) 'Toyota production system and Kanban system Materialization of just-in-time and respect-for-human system', *International Journal of Production Research*, 15(6), p. 553.

Suhr, D. (2005) *SUGI 30 Proceedings*. Philadelphia, Pennsylvania. Available at: http://www2.sas.com/proceedings/sugi30/toc.html#fm.

Suhr, D. (2012) *Step your way through Path Analysis*. University of Northern Colorado.

Suhr, D.D. (2006) *SAS Users Group International*. San Francisco, March 26-29, 2006. California. Available at: http://www2.sas.com/proceedings/sugi31/toc.html.

Sukwadi, R., Wee, H.-M. and Yang, C.-C. (2013) 'Supply Chain Performance Based on the Lean–Agile Operations and Supplier–Firm Partnership: An Empirical Study on the Garment Industry in Indonesia', *Journal of Small Business Management*, 51(2), pp. 297-311.

Suzaki, K. (1987) *The New Manufacturing Challenge: Techniques for Continuous Improvement*. New York London : Free Press Collier Macmillan Publishers.

Suzaki, K. (1993) *The New Shop Floor Management: Empowering People for Continuous Improvement*. New York: The Free Press.

Swamidass, P.M. (1991) 'Empirical Science: New Frontier in Operations Management Research', *The Academy of Management Review*, 16(4), pp. 793-814.

Tabachnick, B.G. and Fidell, L.S. (2007) *Using Multivariate Statistics*. London: Pearson.

Takeda, H. (2006) *The Synchronized Production System: Going Beyond Just-In-Time Through Kaizen*. London, UK and Philadelphia, USA: Kogan Page.

Takeuchi, H., Osono, E. and Shimizu, N. (2008) 'The Contradictions That Drive Toyota's Success', *Harvard Business Review*, 86(6), pp. 96-104.

Tamura, Y. (2006) 'Japanese Production Management and Improvements in Standard Operations: Taylorism, Corrected Taylorism, or Otherwise?', *Asian Business & Management*, 5(4), pp. 507-527.

Taylor, D. and Brunt, D. (2001) *Manufacturing Operations and Supply Chain Management*. first edn (1 vols). Padstow: Thomson Learning.

Taylor, F.W. (1911) *The principles of scientific management* Mineola, N.Y.: Dover Publications.

Tellis, W. (1997) 'Information technology in a university: a case study', *Campus-Wide Information Systems*, 14(3), pp. 78-91.

Terziovski, M. (2002) 'Achieving performance excellence through an integrated strategy of radical innovation and continuous improvement', *Measuring Business Excellence*, 6(2), pp. 5-14.

Terziovski, M. and Sohal, A.S. (2000) 'The adoption of continuous improvement and innovation strategies in Australian manufacturing firms', *Technovation*, 20(10), pp. 539-550.

The Asian Productivity Organization, A. (2013) *Lean Production System*. Available at: http://www.apo-tokyo.org/cgi/apo_p-glossary.pl?record=57 (Accessed: 05/05/2013).

The Morgan Motor (2010) *Morgan Motor Company, 100 not out*. Available at: http://www.morgan-motor.co.uk/about_morgan/the_manufacturer/the_manufacturer/the_manufacturer.html (Accessed: 05/05/2013).

The University of Texas at Austin (2011) *AMOS*. Available at: http://ssc.utexas.edu/software/faqs/amos (Accessed: 05/05/2012).

Thurstone, L.L. (1931) 'Multiple Factor Analysis', *Psychological Bulletin*, 38, pp. 406-427.

Tian, Y., Ellinger, A.E. and Chen, H. (2010) 'Third-party logistics provider customer orientation and customer firm logistics improvement in China', *International Journal of Physical Distribution & Logistics Management*, 40(5), pp. 356-376.

Tillinghurst, D. (1997) 'Kaizen blitz', *Industry Week*, 246(19), pp. 19-27.

Toshiko, N.成. and Shook, J. (2007) *Kaizen Express (英語で kaizen！ トヨタ生産方式 Kaizen Express の詳細)* Second Edition edn. Nikkan Kogyo Shimbunsha (日刊工業新聞社).

Toyota (1995) 'TPS explaination ', *Toyota Production System* [World Wide Web]. Available at: http://www.toyota.co.jp/en/vision/production_system/ (Accessed: 14/11/2007).

Toyota Motor Corporation (1998) *The Toyota Production System*. 1, Toyota-cho, Toyota City, Aichi Prefecture. 471-8571, Japan: Toyota Motor Corporation: Public Affairs Division & Operations Management Consulting Division.

Turnbull, P., Oliver, N. and Wilkinson, B. (1989) 'Recent Developments in the UK Automotive Industry: JIT/TQC and Information Systems', *Technology Analysis & Strategic Management*, 1(4), p. 409.

Turnbull, P., Oliver, N. and Wilkinson, B. (1992) 'Buyer-Supplier Relations in the UK Automotive Industry: Strategic Implications of the Japanese Manufacturing Model', *Strategic Management Journal*, 13(2), pp. 159-168.

ucla: Statistical Consulting Group. (2007) *Introduction to SAS. Factor Analysis Using SAS PROC FACTOR*. Available at: http://www.ats.ucla.edu/stat/sas/library/factor_ut.htm (Accessed: 05/04/2013).

Ullman, J.B. (2007) 'Structural equation modeling', in Tabachnick, B.G. and Fidell, L.S. (eds.) *Using multivariate statistics*. London: Pearson, p. pp. 980.

Utterback, J.M. and Abernathy, W.J. (1975) 'A dynamic model of process and product innovation', *OMEGA*, 3(6), pp. 639-656.

Vaghefi, M.R., Woods, L.A. and Huellmantel, A. (2000) 'Toyota Story 2: Still Winning the Productivity Game', *Business Strategy Review*, 11(1), pp. 59-70.

Valluzzi, J.L., Larson, S.L. and Miller, G.E. (2003) *2003 Joint Statistical Meetings - Section on Survey Research Methods*. Center for Financing, Access, and Cost Trends; 540 Gaither Road, MD 20850. Rockville.

van Dijk, C. and van Den Ende, J. (2002) 'Suggestion systems: transferring employee creativity into practicable ideas', *R&D Management*, 32(5), pp. 387-395.

Veech, D.S. (2004) 'A Person-Centered Approach to Sustaining a Lean Environment-Job Design for Self-Efficacy', *Defense Acquisition Review Journal*, August-November, pp. 159-171.

Verworn, B., Herstatt, C. and Nagahira, A. (2008) 'The fuzzy front end of Japanese new product development projects: impact on success and differences between incremental and radical projects', *R&D Management*, 38(1), pp. 1-19.

Vinodh, S. and Joy, D. (2012) 'Structural Equation Modelling of lean manufacturing practices', *International Journal of Production Research*, 50(6), pp. 1598-1607.

Vokurka, R.J. (1996) 'The relative importance of journals used in operations management research A citation analysis', *Journal of Operations Management*, 14(4), pp. 345-355.

Voss, C., Tsikriktsis, N. and Frohlich, M. (2002) 'Case research in operations management ', *International Journal of Operations & Production Management*, 22(2), pp. 195-219.

Wacker, J.G. (1998) 'A definition of theory: research guidelines for different theory-building research methods in operations management', *Journal of Operations Management*, 16(4), pp. 361-385.

Walford, N. (2009) *Factor Analysis / Principal Components Analysis (FA/PCA)*. Available at: http://cdu.mimas.ac.uk/materials/unit5/2_factor_analysis__principal_components_analysis_fapca.html (Accessed: 20/04).

Walker, J.T. and Maddan, S. (2012) *Statistics in criminology and criminal justice, analysis and interpretation*. Burlington: Jones & Bartlett Publishers.

Wang, J. (2003) '中国第一汽车品牌， 解放 Zhongguo diyi qiche pinpai, jiefang', *中国汽车市场 China Auto Market*, (07), pp. 4-7.

Wang, J. and Cao, D.-b. (2008) 'Relationships between two approaches for planning manufacturing strategy: A strategic approach and a paradigmatic approach', *International Journal of Production Economics*, 115(2), pp. 349-361.

Watanabe, S. (2000) 'The Japan Model and the future of employment and wage systems', *International Labour Review*, 139(3), pp. 307-333.

Watson, G.H., Conti, T. and Kondō, Y. (2003) *Quality Into the 21st Century*. American Society for Qualit.

Webb, A. (2003) 'Toyota teams up with Guangzhou for China venture', *Automotive News Europe*edn), July 14, 2003. [Online] Available at: http://europe.autonews.com/apps/pbcs.dll/article?AID=/20030714/ANE/307140845.

West, S.G., Finch, J.F. and Curran, P.J. (1995) 'Structural equation models with nonnormal variables: Problems and remedies.', in Hoyle, R.H. (ed.) *Structural equation modeling: Concepts, issues, and applications*. Thousand Oaks, CA: SAGE, pp. 56-75.

Whaples, R. and Betts, D.C. (1995) *Historical Perspectives on the American Economy*. Cambridge University Press.

Williams, K., Haslam, C., Williams, J., Adcroft, A. and Johal, S. (1993) 'The Myth of the Line: Ford's Production of the Model T at Highland Park, 1909-16', *Business History*, 35(3), pp. 66-87.

Winfield, I. (1994) 'Toyota UK Ltd: Model HRM Practices?', *employee Relations*, 16(1), pp. 41-53.

Womack, J.P. and Jones, D.T. (1996) *Lean Thinking: banish waste and create wealth in your corporation*. New York: Simon & Schuster.

Womack, J.P. and Jones, D.T. (2005) *Lean Solutions, How companies and Customers Can Create Value and Wealth Together*. London: Simon & Schuster UK Ltd.

Womack, J.P., Jones, D.T. and Roos, D. (1990) *The Machine That Changed the World: The Story of Lean Production* New York: Rawson Associates.

Wood, G.R. and Munshi, K.F. (1991) 'Hoshin Kanri: A systematic approach to breakthrough', *Total Quality Management*, 2(3), pp. 213-226.

Worthke, W. (2013) *Most Frequently Asked Questions about Amos*. Available at: http://www.smallwaters.com/amos/faq/faqa-mfaq.html#a_mfaq3 (Accessed: 11/11/2013).

Wright, S. (1918) 'On the nature of size factors', *Genetics*, 3, pp. 367-374.

Wright, S. (1921) 'Correlation and causation', *Journal of Agricultural Research*, 20(7), pp. 557-585.

Wright, S. (1934) 'The method of path coefficients', *The Annals of Mathematical Statistics*, 5(3), pp. 161-215.

Wright, S. (1960) 'Path Coefficients and Path Regressions: Alternative or Complementary Concepts?', *Biometrics*, 16(2), pp. 189-202.

Wu, M. (2009) *Jiegou Fangcheng Moxing - AMOS de changzuo yu yingyong*. Chongqin: Chongqin Daxue Chubanshe.

Xiao, Q. (2003) '中国汽车话百年 Zhongguo qiche hua bainian', *交通与运输 Traffic & Transportation*, (3), pp. 43-44.

Xing, Y. (2010) 'The role of Japan in China's three-decade economic reform', in Wong, J. and Bo, Z. (eds.) *China's reform in global perspective*. Danvers: World Scientific Publishing Co. Pte. Ltd., pp. 117-138.

Yamamoto, Y. (2010) *Kaikaku in Production*. Phd thesis. Malardalen University Sweden.

Yang, M.G.M., Hong, P. and Modi, S.B. (2011) 'Impact of lean manufacturing and environmental management on business performance: an empirical study of manufacturing firms', *International Journal of Production Economics*, 129, pp. 251-261.

Yasuda, Y. (1989) *Toyota no soi kufuteian Katsudo (40 years, 20 million ideas, The Toyota Suggestion System)*. Translated by Czupryna, F. Tokyo: Japan Management Association.

Yin, R.K. (2003a) *Applications of Case Study Research*. Third Edition edn. SAGE Publication Inc.

Yin, R.K. (2003b) *Case Study Research: Design and Methods*. Thousand Oaks, London, New Delhi: SAGE.

Yoneyama, E. (2007) 'Phenomenology of life, Zen and management', *Society and Business Review*, 2(2), pp. 204-217.

Yuan, K.-H., Wu, R. and Bentler, P.M. (2010) 'Ridge Structural Equation Modeling with Correlation Matrices for Ordinal and Continuous Data', *Br J Math Stat Psychol*, PMC3103762, pp. 1-39.

Yung, Y.-F. (2010) 'Introduction to Structural Equation Modeling Using the CALIS Procedure in SAS/STAT® Software', *Computer technology workshop (CE_25T)*. Vancouver, Canada. .

Zeng, J., Phan, C. and Matsui, Y. (2013) 'Supply chain quality management practices and performance: An empirical study', *Operations Management Research*, pp. 1-13.

Zhang, H. (2006) '东风零部件出口营销初探 Dengfeng lingbujian chukou yingxiao chutan', *Group Economy 集团经济研究* 2006(22).

Zhang, W. and Alon, I. (2010) *A guide to top 100 companies in China*. Danvers: World Scientific Publishing Co. Pte. Ltd.

Zhang, Y. (2008) 'topten car manufacturers', *1 月份全国汽车销量十大轿车厂家三分天下有其二 yiyuefen quanguo qiche xiaoliang shida jiaoche changjia sanfentianxia you qi er*. Available at: http://news.xinhuanet.com/auto/2008-02/21/content_7638218.htm (Accessed: 30/03/2008).

Zhao, N. (2009) *The Minimum Sample Size in Factor Analysis*. Available at: http://www.encorewiki.org/display/~nzhao/The+Minimum+Sample+Size+in+Factor+Analysis (Accessed: 02/2013).

Zhao, P. (2006) '解放-民族汽车品牌的基石 jiefang-mingzhu qiche pingpai de jishi', *驾驶园 World of Driver*, (7), pp. 1-1.

Zhou, W., Xu, X. and Ye, F. (2012) 'Interrelationships among Lean Production Elements', *Chinese Journal of Management*, 9(8), pp. 1211-1217.

Zikmund, W.G., Babin, B.J., Carr, J.C. and Griffin, M. (2010) *Business Research Methods*. Nine edn. Erin Joyner.

Zubir, A.F.M. and Habidin, N.F. (2012) 'The Development of Sustainable Manufacturing Practices and Sustainable Performance in Malaysian Automotive Industry', *Journal of Economics and Sustainable Development* 3(7), pp. 130-139.